ENEE408G Multimedia Signal Processing
Mobile Computing and Pocket PC Programming Manual

Guan-Ming Su

Min Wu

K. J. Ray Liu

Department of Electrical and Computer Engineering
University of Maryland at College park

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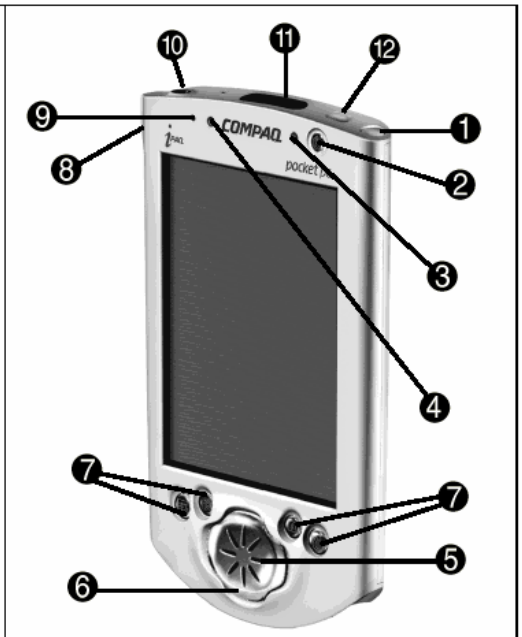
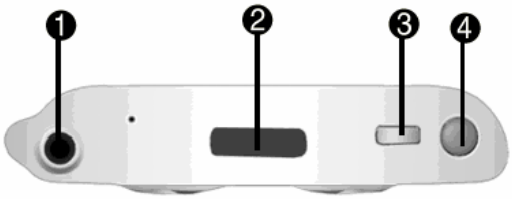
Part I. A Brief Introduction to Pocket PC

1. Compaq iPAQ Pocket PC H3760 Series[1]

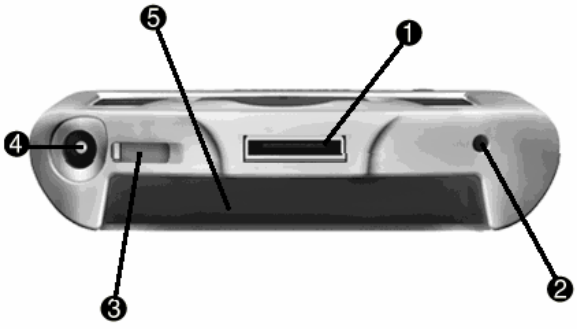
Front Panel

❶ Stylus: tap, draw, or write ❷ Power Button ❸ Power Indicator: alarm charge light ❹ Light sensor: adjusts backlight ❺ Speaker ❻ iPAQ Navigation/Action Button 5: scroll through a list, open a selected item ❼ Programmable Application Buttons 1-4 (left to right): navigate to applications, default: button 1 is Calendar, button 2 is Contacts, button 3 is Inbox, button 4 is iPAQ Task ❽ Record Button ❾ Microphone ❿ Stereo Headphone Jack ⓫ Infrared Port: exchange information with other Windows-powered devices ⓬ Stylus Release Button: eject the stylus	

Top panel

❶ Stereo Headphone Jack ❷ Infrared Port: exchange information with other Windows-powered devices ❸ Stylus Release Button: eject the stylus ❹ Stylus: tap, draw, or write	

Bottom Panel

❶ Communications Port: connect to cradle, USB, or serial cable. ❷ Reset Button: reset with stylus ❸ On/Off Switch: clear all information ❹ DC Jack: connect to external power ❺ iPAQ Expansion Pack Connector: connect to an optional Expansion Pack	

[1] From Compaq iPAQ Pocket PC H3700 Series reference Guide from iPAQ H3760 Package CD.

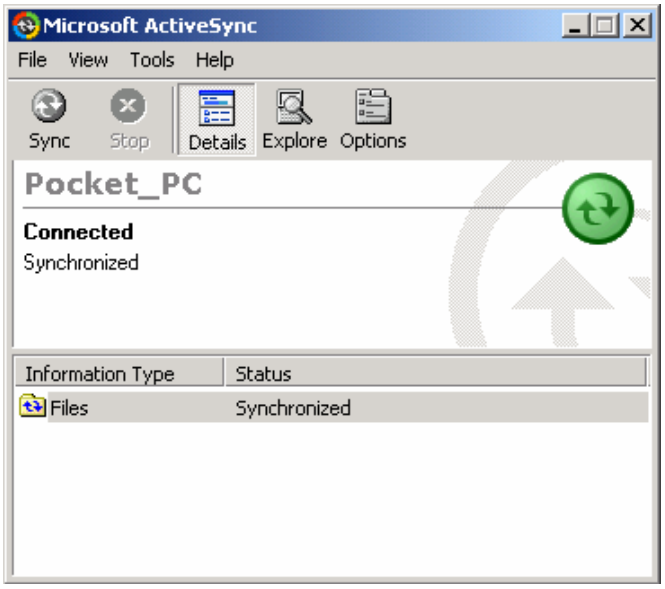
2. Operating Pocket PC

A useful document explaining how to operate and use the iPAQ can be found in the CD of your iPAQ package. Under the directory, *COMPAQ/Docs/*, you can find a file named *PPC PDF H3700.pdf*. You can start with reading this reference.

You can check out the eBook, *How to do everything with your Pocket PC* at www.netlibrary.com. This eBook gives many examples explaining how to use Pocket PC in our daily life.

3. Microsoft ActiveSync:

Microsoft ActiveSync is an interface for transferring files and communicating between Pocket PC and Desktop PC. If you have your own PC, you can create a *Partnership* between these two devices. Every file under the Desktop PC folder, *Pocket PC My Documents*, and the Pocket PC folder, *My Document*, will be synchronized. If you are using a PC in Jasmine, you can be a *Guest* without setting up a *Partnership*.



The figure above shows the Microsoft ActiveSync Window. You can transfer files by clicking the "*Explore*" button. A window that is similar to PC's *File Explorer* Window will pop up. For more details about Microsoft ActiveSync, please refer to the above-mentioned document, *PPC PDF H3700.pdf* .

Part II. Microsoft Windows® Platform SDK for Pocket PC[2]

1. Desktop WinCE Emulation

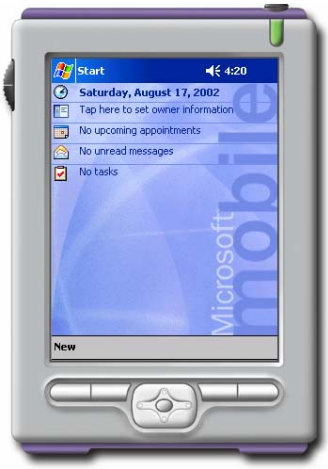
The WinCE emulator can be executed from *Start → Programs → 408g → Microsoft Windows Platform SDK for Pocket PC → Desktop Pocket PC Emulation*. You will see a window shown in the left figure below.

We can use this emulator to test our applications without the physical device. However, this emulator doesn't support all Pocket PC's functionalities. Note that the execution time of programs on emulator is faster than on real device. The emulator has its own directory in desktop PC, which is in *c:\Windows CE Tools\wce300\MS Pocket PC\ emulation\palm300.* This directory emulates the root directory of a physical Pocket PC device.

2. Desktop Pocket PC 2002 Emulation[3]

The device we use in this course runs on an operating system known as Microsoft Pocket PC 2002. The emulator for this device is Pocket PC 2002 emulator and we will use it most of the time. You can find this executable program under *C:\Program Files\Windows CE Tools\ Common\Playman\bin\Emulator.exe*.

WinCE Emulator



Pocket PC 2002 Emulator

[2] The Microsoft Windows® Platform SDK for Pocket PC and eMbedded Visual Tools (in Part III) can be downloaded from http://www.microsoft.com/mobile/developer/downloads/default.asp

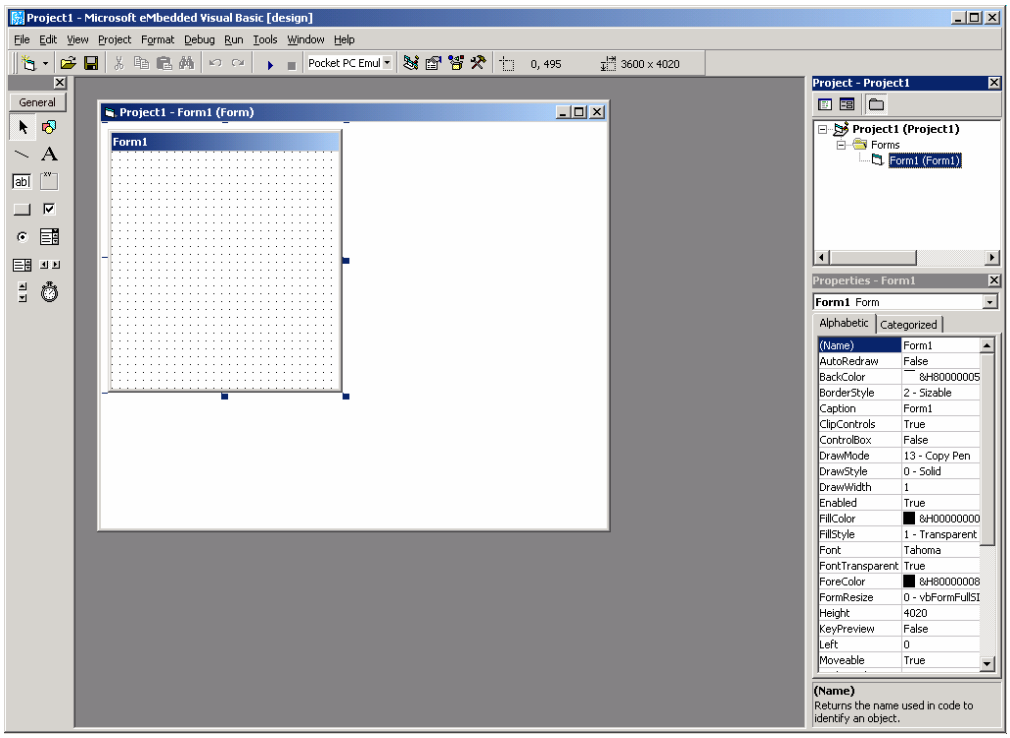
[3] Pocket PC 2002 SDK can be downloaded from http://www.microsoft.com/mobile/developer/downloads/ppcsdk2002.asp

Part III. Microsoft embedded Visual Basic 3.0

1.Design Environment and Programming

(a) Integrated Development Environment (IDE)

The figure below shows the eMbedded Visual Basic (eVB) IDE. The left part is the *Toolbox Window*. This window offers several components for building graphical user interface in most applications. The lower right part is the *Properties Window*. We can set the properties of each component, such as the height, width, caption, and background color. The upper right part is the *Project Explorer*. It indicates which forms and modules are in this project. The middle part shows the *Form Window* and the corresponding *Code Windows*. A *form* is a graphical interface shown on Pocket PC. Programmers can design the interface directly by clicking and dragging the components from the *Toolbox Window* to the *Form Window*. We can put the codes that respond to events and components in the *Code Window*, which can be opened by double clicking a component, or selecting from the menu bar *View* → *Code*.



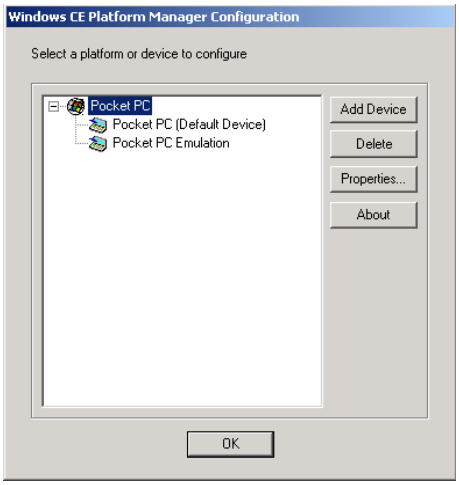
(b) Remote Tools

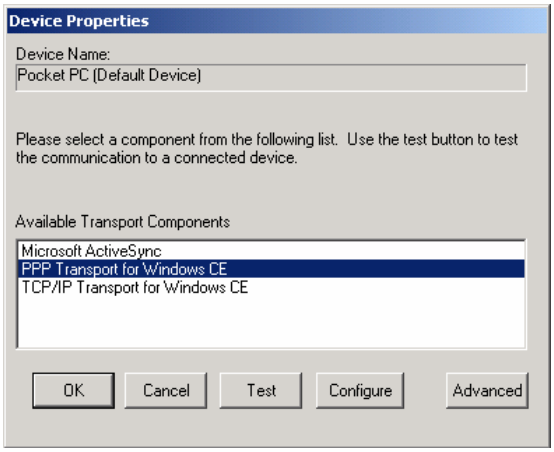
There are several useful tools under *Tools* → *Remote Tools*

(1) Windows CE Platform Manager Configuration

The left figure below shows the *Configure Platform Manager*. We use this manager to build initial connection between desktop and Pocket PC. After setting up the connection, we can execute the eVB codes on Pocket PC.

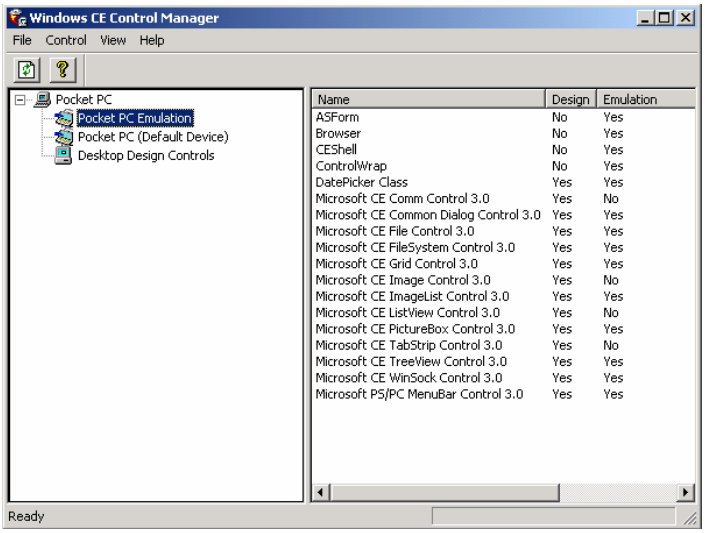
Choose *Pocket PC (Default Device) or Pocket PC 2002 (Default Device)* by double clicking that item. Another window called *Device Properties* as shown in the right figure below will pop up. There are three different ways to build connection. The first transport component, Microsoft ActiveSync, usually works well. If not, try the TCP/IP and PPP transport.





(2) Windows CE Control Manager

Another useful tool is the *Control Manager*, in which we can add ActiveX Controls[4] (.dll, .ocx). By clicking the device and selecting *Control → Add New Control* from menu bar, we can easily add controls[5].


Windows CE Control Manager
File Control View Help
Pocket PC
Pocket PC Emulation
Pocket PC (Default Device)
Desktop Design Controls
Name Design Emulation
ASForm No Yes
Browser No Yes
CEShell No Yes
ControlWrap No Yes
DatePicker Class Yes Yes
Microsoft CE Comm Control 3.0 Yes No
Microsoft CE Common Dialog Control 3.0 Yes Yes
Microsoft CE File Control 3.0 Yes Yes
Microsoft CE FileSystem Control 3.0 Yes Yes
Microsoft CE Grid Control 3.0 Yes Yes
Microsoft CE Image Control 3.0 Yes No
Microsoft CE ImageList Control 3.0 Yes Yes
Microsoft CE ListView Control 3.0 Yes No
Microsoft CE PictureBox Control 3.0 Yes Yes
Microsoft CE TabStrip Control 3.0 Yes No
Microsoft CE TreeView Control 3.0 Yes Yes
Microsoft CE WinSock Control 3.0 Yes Yes
Microsoft PS/PC MenuBar Control 3.0 Yes Yes
Ready

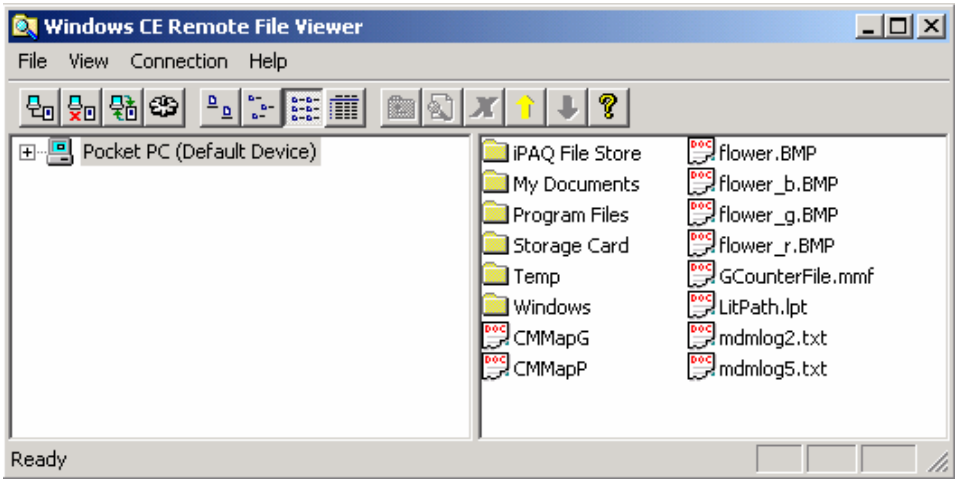
(3) Windows CE Remote File Viewer

After setting the *Windows CE Platform Manager Configuration*, we can use *Windows CE Remote File Viewer* to view, import and export files in the

[4] An *ActiveX control*, like a built-in control, is an object that you put on a form to enable or enhance a user's interaction with an application. ActiveX controls have events and can be incorporated into other controls

[5] To enable the new ActiveX Control in eVB, we need the corresponding version in your PC. Under Windows 2000 *Command Prompt* window, use command "*regsvr32 dllname*" to register a new control.

Pocket PC or Pocket PC emulator. To import/export files, you can use the yellow arrows in the toolbar.

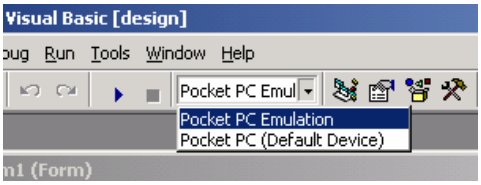


(4) Zoom

Zoom is a tool for capturing a screen display.

(c) Choosing device

While running the eVB program, we can choose to run it under an emulator or the physical device from the following list box.



(d) Reference and Component

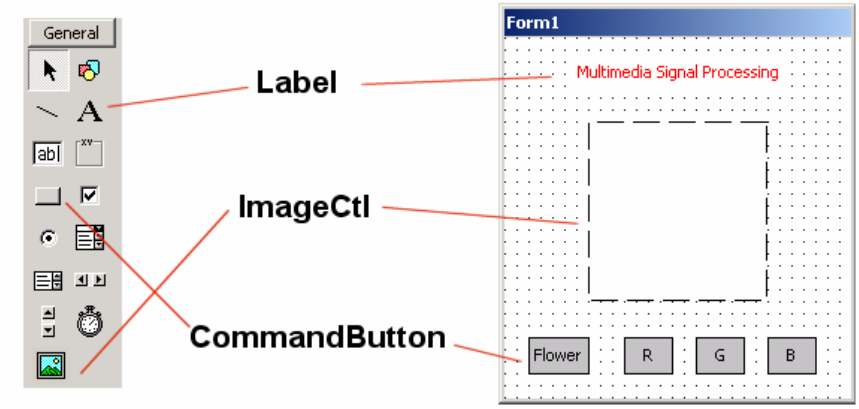
Except the components shown in the *Toolbox Window*, we could add more components from *Project* → *Reference* and *Components* in the eVB menu bar.

2. Build A Simple Program

In this sub-section, we implement a simple eVB program. Programming under eMbedded Visual Basic is similar to Programming using Visual Basic under PC 's Visual Studio environment

(a) Click *File* → *New Project* from the eVB menu bar and choose *Windows CE for the Pocket PC Project*.

(b) From the *Toolbox Window*, drag [6] four *CommandButton* objects and one *Label* object to the form. The layout is shown as follows.



In the *Properties Window*, change the *Name* property of the four *CommandButton*s to "*bnOriginal*", "*bnR*", "*bnG*", "*bnB*", respectively. Change the *Caption* property of those *CommandButtons* to "*Flower*", "*R*", "*G*", "*B*", respectively. Change the *Caption* property of *Label* to "*Multimedia Signal Processing*".

(c) To add an *ImageCtl* object on the form, choose *Microsoft CE Image Control 3.0* from *Project* → *Components*. An *ImageCtl* icon will appear on the *Toolbox*. Drag it to the form. Adjust its *Height* and *Width* properties to fit in the form.

(d) After setting properties, type the following codes in the *Code Window*.

```
Option Explicit

Private Sub bnOriginal_Click()
   ImageCtl1.Picture = "flower.BMP"
   ImageCtl1.Refresh
End Sub

Private Sub bnR_Click()
   ImageCtl1.Picture = "flower_r.BMP"
   ImageCtl1.Refresh
End Sub
```

[6] Here by "dragging" a button we mean the following actions: click the button icon in the *Toolbox* window, and then use your mouse to draw a bounding box on the form. A button with a default name and attributes will show up in the bounding box. You can create other objects in a similar way.

```
Private Sub bnG_Click()
   ImageCtl1.Picture = "flower_g.BMP"
   ImageCtl1.Refresh
End Sub

Private Sub bnB_Click()
   ImageCtl1.Picture = "flower_b.BMP"
   ImageCtl1.Refresh
End Sub

Private Sub Form_Load()
   ImageCtl1.Picture = "flower.BMP"
   ImageCtl1.Refresh
End Sub

Private Sub Form_OKClick()
   App.End
End Sub
```

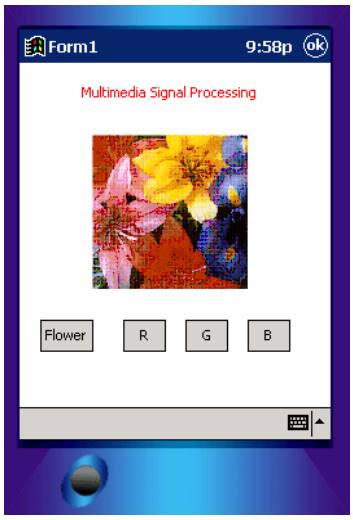
The last sub-function is for terminating the program when we click the *OK* button in the upper-right side of the form.

(e) Put the files *flower.BMP*, *flower_r.BMP*, *flower_g.BMP* and *flower_b.BMP*[7] in the directory, *C:\ Windows CE Tools\wce300\MS Pocket PC\ emulation\ palm300*.

(f) Save the project and files by *File* → *Save Project As*.

(g) Select the device as *Pocket PC emulation*.

(h) Click *Run* → *Execute* from the eVB menu bar and the result will be shown in the emulator. You can use your mouse to click those buttons to see what happens. Under the emulation environment, the mouse emulates the behavior of stylus.



[7] You can download those files from course web site. It is noteworthy that Pocket PC supports at most 16 bits to represent a color image. You can reduce the color depth by using image processing software, such as Paint Shop Pro.

3. Distribute eMbedded Visual Basic Application

Step 1. Make the project by *File* → *Make projectname.vb…* Then use the Application Install Wizard by *Tools*→*Remote Tools*→*Application Install Wizard,*

Step 2. Enter the full path to the eMbedded Basic Project (.EBP) file.

Step 3. Enter the full path to the compiled eMbedded Basic Application file (.VB)

Step 4. Enter the directory in which all output files will be created.

Step 5. Select the processors you would like to support. To support iPAQ H3760, the device we use in this course, choose *Arm 1100*.

Step 6. Select any additional ActiveX controls or references that you want to install.

Step 7. Specify any additional data files.

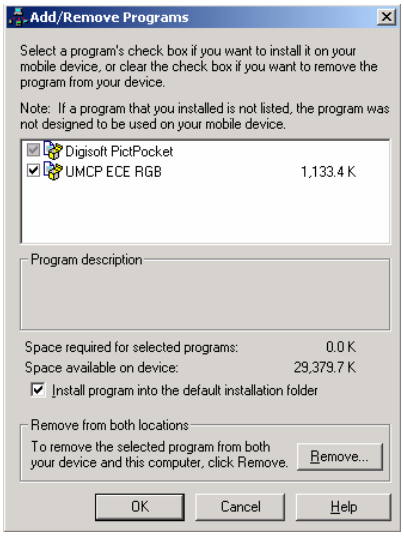
Step 8. Provide the information about the default installation directory (under \Program Files), application name, description and company name.

Step 9. Finish creating the Installation Program.

4. Install the Software Program in Pocket PC

(a) Go to the output directory set in Step 4 in previous section. Go down to the *CD1* sub-directory and click the *Setup.exe.*

(b) You will be asked for a temporary directory to store files. Specify a directory and an *Add/Remove Programs* Window will pop up. Follow the instructions to finish the installation.


Add/Remove Programs
Select a program's check box if you want to install it on your mobile device, or clear the check box if you want to remove the program from your device.
Note: If a program that you installed is not listed, the program was not designed to be used on your mobile device.
Digisoft PictPocket
UMCP ECE RGB
1,133.4 K
Program description
Space required for selected programs:
0.0 K
Space available on device:
29,379.7 K
Install program into the default installation folder
Remove from both locations
To remove the selected program from both your device and this computer, click Remove.
Remove...
OK
Cancel
Help

5. Add More Components to A Project

In this section, we continue with the previous RGB example to explain how to add various components in eVB. We will move the functions implemented by buttons to menu items, create a simple text editor, and learn how to open and save files.

(a) Create a new Pocket PC project. From *Project* → *Components*, check the *Pocket PC MenuBar Control 3.0, Microsoft CE File System Control 3.0,* and *Microsoft CE Image Control 3.0.* Then click *OK.*

(b) Double click the *MenuBar* and *File* in the *Toolbox* and they will appear in the *Form* window. It doesn't matter where those components locate since they will be invisible during runtime. We set their *Names* as "*MenuBar1"* and "*File1*", respectively.

(c) Set properties for the components created according to table below.

Component	Name	Caption/Text	Visible	Scrollbars
ImageCtl	*ImageCtl1*		*True*	
commandButton	*bnSave*	*Save*	*False*	
Label	*Label1*	*File name with path*	*False*	
TextBox	*Text1*	*""*	*False*	*2-vbVertical*
TextBox	*Text2*	*""*	*False*	*0-vbSBNone*

Set both *Width* and *Height* of *ImageCtl1* and *Text1* as 2400, and *Top* and *Left* as 1080 and 600, respectively. In other words, we make these two components overlap with each other. Put the *Label1, Text2*, and *bnSave* in the upper, middle and lower part of the form, respectively. Don't worry about their overlapping with the *ImageCtl1* and *TextBox*, since they work in different occasion and some of them will be set to invisible.

(d) After finishing the layout, let's work on the codes for *MenuBar* control first. We will create two *dropmenu*s. One is for the RGB used in the previous example and the other is for the text editor. As shown in the following figure, we initially set the RGB part visible and the text editor invisible.

```
Option Explicit

Private Sub Form_Load()
   Dim mnuDropMenu As MenuBarLib.MenuBarMenu
   Set mnuDropMenu = MenuBar1.Controls.AddMenu("Colors", "mnuColors")
   mnuDropMenu.Items.Add , "mnuColorsR", "Red"
   mnuDropMenu.Items.Add , "mnuColorsG", "Green"
   mnuDropMenu.Items.Add , "mnuColorsB", "Blue"
   mnuDropMenu.Items.Add , , , mbrMenuSeparator
   mnuDropMenu.Items.Add , "mnuColorsO", "Flower"

   Set mnuDropMenu = MenuBar1.Controls.AddMenu("Text", "mnuText")
   mnuDropMenu.Items.Add , "mnuSave", "Save"
```

```
    mnuDropMenu.Items.Add , "mnuOpen", "Open"
    mnuDropMenu.Items.Add , "mnuNew", "New"

    ImageCtl1.Picture = "flower.BMP"
    ImageCtl1.Refresh
    Text1.Visible = False
    Text1.Text = ""
    Text2.Visible = False
    Text2.Text = ""
End Sub

Private Sub Form_OKClick()
    App.End
End Sub
```

(e) Then, we should write a *Select* statement to respond to different menu event. In each *Case*, we call a sub-function to react to each event.

```
Private Sub MenuBar1_MenuClick(ByVal Item As MenuBarLib.Item)
Select Case Item.Key
    Case "mnuColorsR"
        rearrange_colors "flower_r.BMP"
    Case "mnuColorsG"
        rearrange_colors "flower_g.BMP"
    Case "mnuColorsB"
        rearrange_colors "flower_b.BMP"
    Case "mnuColorsO"
        rearrange_colors "flower.BMP"
    Case "mnuSave"
        aIO_File False, True, "Save"
    Case "mnuOpen"
        aIO_File False, True, "Open"
    Case "mnuNew"
        aCreate_NewFile
End Select
End Sub
```

(f) The last step is to write the sub-functions to deal with those responses.

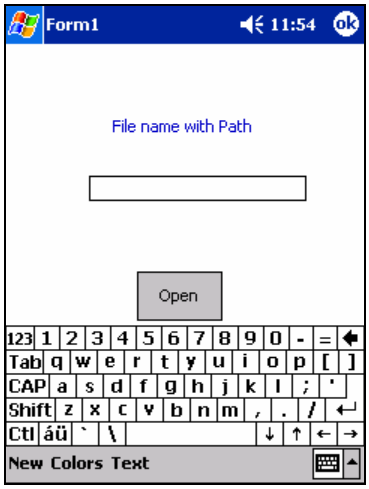
```
Private Sub rearrange_colors(ByVal path As String)
        Label1.Visible = False
        Text1.Visible = False
        Text1.Enabled = False
        Text2.Visible = False
        Text2.Enabled = False
        bnSave.Visible = False
        bnSave.Enabled = False
        ImageCtl1.Visible = True
        ImageCtl1.Picture = path
        ImageCtl1.Refresh
End Sub

Private Sub aIO_File(ByVal txt1B As Boolean, ByVal txt2B As Boolean, ByVal_
bnCaption As String)
```

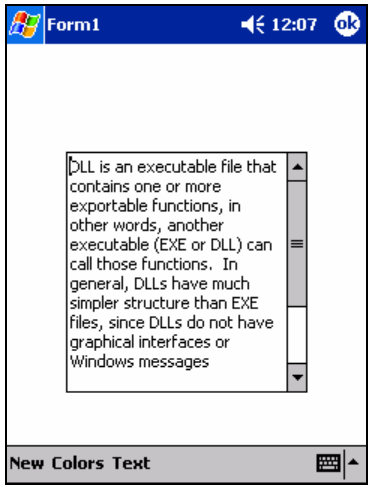
```
        Text1.Visible = txt1B
        bnSave.Visible = True
        bnSave.Caption = bnCaption
        bnSave.Enabled = True
        Label1.Visible = True
        ImageCtl1.Visible = False
        Text2.Visible = txt2B
        Text2.Enabled = txt2B
        Text2.Text = ""
        SIPVisible = True
    End Sub

    Private Sub aCreate_NewFile()
        Text1.Visible = True
        ImageCtl1.Visible = False
        Text1.Text = ""
        Text1.Enabled = True
        SIPVisible = True
    End Sub

    Private Sub bnSave_Click()
        If InStr(bnSave.Caption, "Save") Then
          File1.Open Text2.Text, fsModeOutput, fsAccessWrite, fsLockWrite
          File1.LinePrint Text1.Text
          Text1.Visible = False
          Text1.Text = ""
          SIPVisible = False
          MsgBox "Save OK"
        Else
          Dim s
          File1.Open Text2.Text, fsModeInput, fsAccessRead, fsLockWrite
          Do While Not File1.EOF
            s = File1.LineInputString
            Text1.Text = s
          Loop
          Text1.Visible = True
          Text1.Enabled = True
          SIPVisible = False
        End If
        File1.Close
        Text2.Visible = False
        Text2.Text = ""
        Label1.Visible = False
        bnSave.Visible = False
    End Sub
```

SIPVisible is a controller for the *Soft Input Panel*, the formal name of the keyboard on Pocket PC screen. Users will find it convenient if we set SIP as visible in some occasions.

(g) Now, we have finished the coding part. We can execute this program to see the result. The figures below show the menu we have designed.

The left figure below shows the result after selecting *Text* → *Open*. The right figure shows the result of a file after we enter a file name and click the *Open* button.




Form1
12:07
ok
DLL is an executable file that contains one or more exportable functions, in other words, another executable (EXE or DLL) can call those functions. In general, DLLs have much simpler structure than EXE files, since DLLs do not have graphical interfaces or Windows messages
New Colors Text

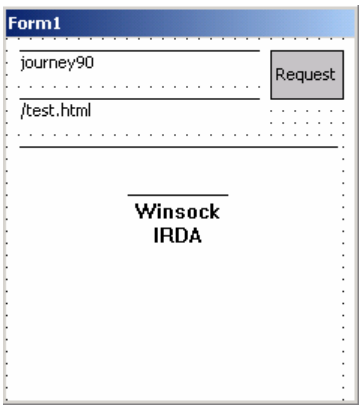
6. Winsock – TCP/IP and InfraRed Communication

Mobility is one of the most important characteristics of Pocket PC. It provides the versatile capabilities for Pocket PC to communicate with other devices. eMbedded Visual Basic offers Winsock control to set up sockets[8] between devices. In this section, we implement a small program for HTTP request using Winsock control.

(1) Include *Microsoft Widows CE Winsock Control 3.0* using *Project* → *Components*.

(2) Layout a form as follows and set the properties of the components according to the table below.

[8] Sockets are software layer between the application and transfer protocol on network communications.



Component	Name	Caption/Text	Scrollbars
Winsock	*Winsock1*		
commandButton	*btnRequest*	*Request*	
TextBox	*txtServer*	*"server name"*	*0-vbSBNone*
TextBox	*txtResource*	*"/test.html"*	*0-vbSBNone*
TextBox	*txtOutput*	*""*	*2-vbVertical*

Set the *Protocol* property of *Winsock1* as *0-sckTCPProtocol*.

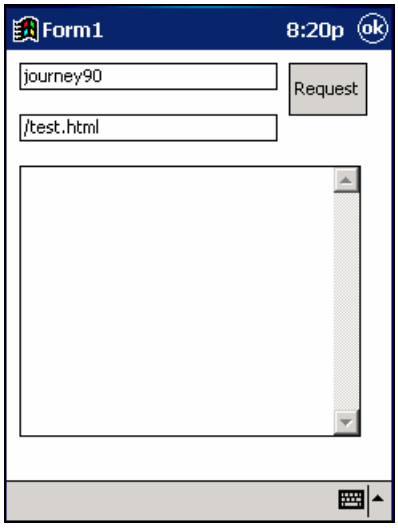
(3) Codes:

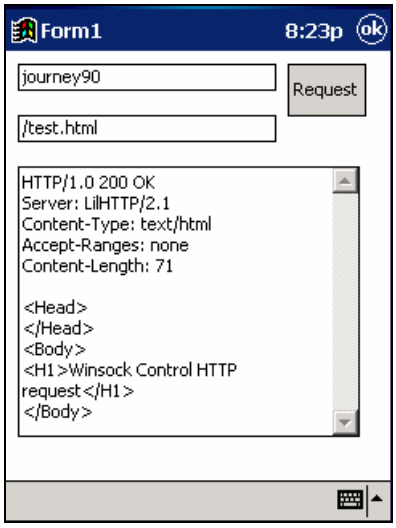
```
Option Explicit

Private Sub btnRequest_Click()
   Dim s
   On Error Resume Next
      WinSock1.Close
      WinSock1.RemoteHost = txtServer.Text
      WinSock1.RemotePort = 80
      WinSock1.Connect
      txtOutput.Text = ""
      If Err.Number <> 0 Then
         MsgBox "Error:" & Err.Number & vbCrLf & Err.Description
      End If
      s = "GET" & txtResource.Text & vbCrLf & vbCrLf
      WinSock1.SendData s
      If Err.Number <> 0 Then
         MsgBox "Error:" & Err.Number & vbCrLf & Err.Description
      End If
End Sub

Private Sub Form_OKClick()
   App.End
End Sub

Private Sub WinSock1_DataArrival(ByVal bytesTotal As Long)
   Dim sRecieveDate
   On Error Resume Next
      WinSock1.GetData sRecieveDate
```

```
        If Err.Number <> 0 Then
           MsgBox "Error:" & Err.Number & vbCrLf & Err.Description
        Else
           txtOutput.Text = sRecieveDate
           WinSock1.Close
        End If
    End Sub
```

We set the *Winsock1.RemoteHost* as the server's name[9] and *RemotePort* as the default port 80 for HTTP. *Winsock1.Connect* sets up a connection between two devices. If the connection is successfully established, the client and server can transfer data to each other through *Winsock1.SendData* and *Winsock1.Getdata*. If other device sends data to Pocket PC, it will trigger the *Winsock1_DataArrival* and we will be able to deal with the incoming data. As shown above, we use *On Error Resume Next* to catch any run time error. The *Err* object contains the information about the error.

(4) Make sure the http server is working and put a text file in the www root directory, so that we can run a test by setting the server name and the file we want to get. The left figure below shows the program interface. After requesting, we get the file in the *txtOutput* Window shown in the right figure below.





7. Windows CE API

(a) In addition to the ActiveX controls, we can extend the ability of eMbedded Visual Basic by calling procedures included in the Windows CE API (Application Programming Interface). The Windows CE API can be regarded as a subset of the

[9] In this case, it's the machine we used with eVB. Make sure there exists an http server inside the machine If there is no http server inside your machine, you can download the freeware "Lil' HTTP server" from http://www.summitcn.com/ and install it. Set the port, IP and server name and then start it.

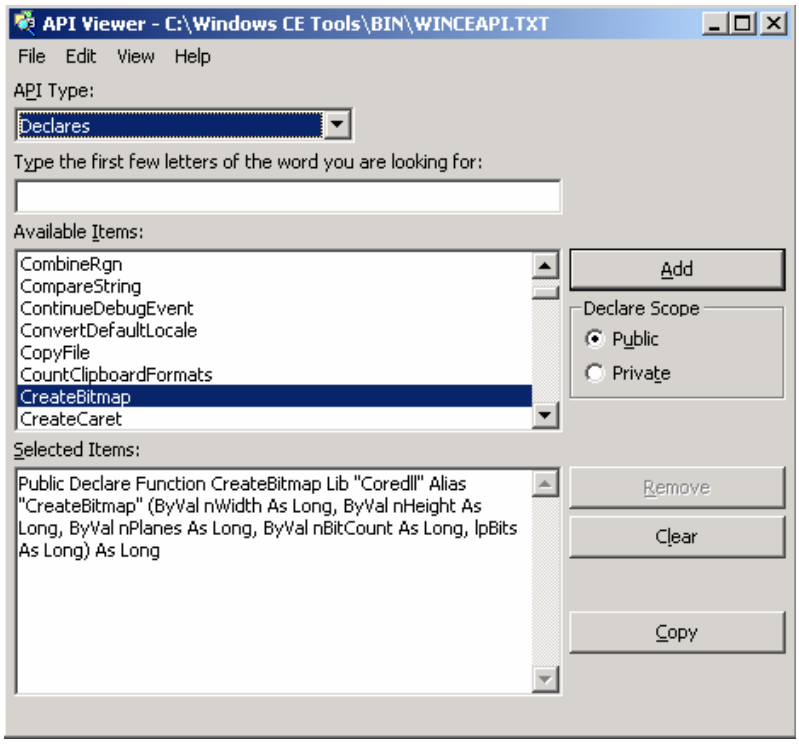
Microsoft Win32 API. Those API's are a collection of dynamic-link libraries (DLLs[10]) containing many procedures used by Windows-based desktop platforms. With these DLLs, we can expand the eVB capability, such as displaying windows and graphics, managing memory and power, and accessing persistent storage, which cannot be done by built-in controls.

Windows CE platform SDK for Pocket PC provides a text file, *Winceapi.txt*, that contains predefined declarations for many of the Windows CE API procedures commonly used in eMbedded Visual Basic applications. To call those functions, we should follow the syntax:

[Scope] Declare Function|Sub {*FunctionName*} Lib "{*Library File Name*}" _
[Alias "Library Function Name"] _
({*Function Parameter List*}) As {*Function Return*}

We can use the convenient *API Viewer t*o use those Constants, Declares, or Types from this file.

(1) First, we run an *API Viewer* from *Start* → *Programs* → *408g* → *Microsoft eMbedded Visual Tools* → *Tools* → *Api Text Viewer*.



[10] DLL is an executable file that contains one or more exportable functions. In other words, another executable files (EXE or DLL) can call those functions. In general, DLLs have much simpler structure than EXE files, since DLLs do not have graphical interfaces or Windows message processors. However, we cannot use eMbedded Visual Basic to create our own DLLs. We can make API calls from eVB, instead.

(2) From *File* → *Open* on the *API Viewer* menu bar, select *winceapi.txt* file from the directory *C:\Windows CE Tools\ Bin* .
(3) Choose the desired *API Type* and pick an item in the *Available Items* list box. Click the *Add* button and the syntax of the selected item will appear in the bottom textbox. We can copy those declarations and paste them in our eVB program.

(4) To use those APIs, we must put the corresponding declarations in a module (.bas file, not the form file) and must put them in the *General Declarations* section.

(b) Example

In this example, we simply call the *Playsound* function. First, create a new Windows CE Pocket PC Project, put a *Commandbutton* on the form. Rename the *Name* of *Commandbutton* as "*bnPlaySound"*. Put the following codes in the form

```
Option Explicit
Dim af As Long

Private Sub bnPlaySound_Click()
   Dim title_wave As String
   title_wave = "\\Windows\\Alarm1.WAV"
   music_play (title_wave)
End Sub

Private Sub Form_OKClick()
   App.End
End Sub
```

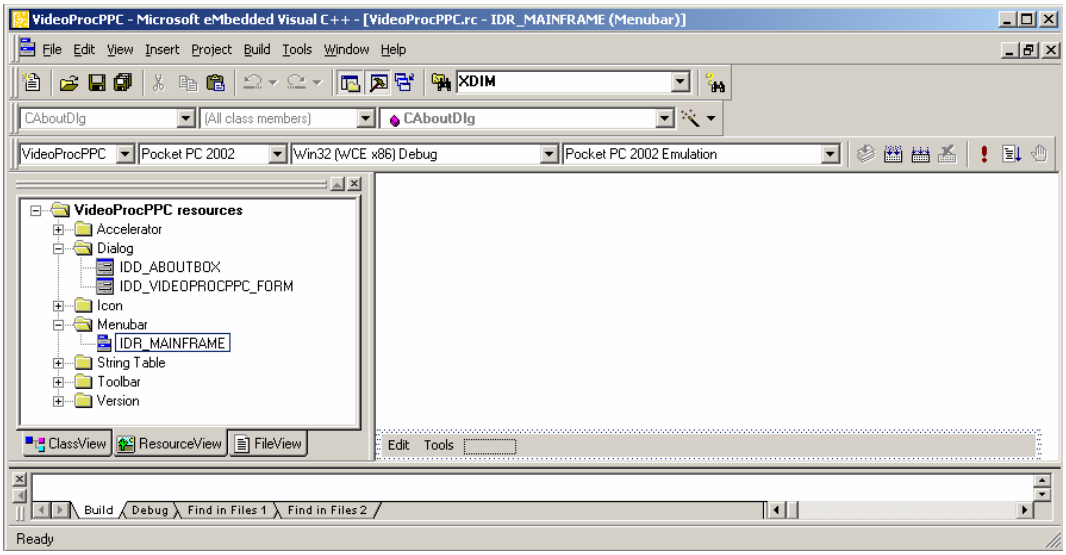
We add a new module by *Porject* → *Add Module*. We add the *Playsound* API declaration in this module. The declaration can be obtained according to what we have learned in the previous sub-section. The constant *SND_SYNC* is also obtained in the same way. Put the following codes in this module.

```
Option Explicit
Public Const SND_SYNC = &H0
Public Declare Function PlaySound Lib "Coredll" Alias "PlaySoundW"_
(ByVal lpszName As String, ByVal hModule As Long, ByVal dwFlags As _
Long) As Long

Private Sub music_play(ByVal music_filename As String)
  Dim af As Long
  af = PlaySound(music_filename, 0, SND_SYNC)
End Sub
```

After finishing these settings, we can play *alarm1.wav* by clicking the button.

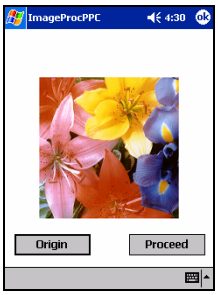
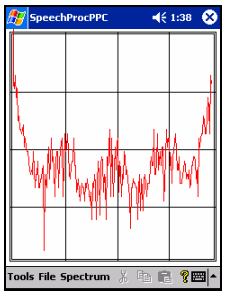
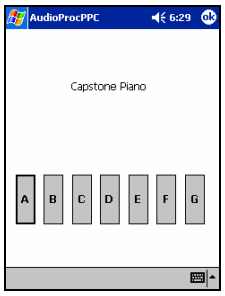
Part IV. Microsoft eMbedded Visual C++ 3.0 (eVC) [11]

1. Integrated Design Environment (IDE)



Microsoft eMbedded Visual C++ (eVC) has almost the same appearance as the IDE of VC. The window to the left is the *Project Workspace Window*, which shows the current classes, resources[12], and files used in your project. The window to the right is the *Edit Window* and you may do coding and edit menus, dialog boxes here. The window at the bottom is the *Output Window* and it will display messages that result from compiling and linking your program.

The tools under eVC menu bar *Tools* are the same as eVB. Please refer to Section III.1. (b). In the following sections, we use four demo projects related to multimedia signal processing as a guideline to eVC programming. In section IV.6 troubleshooting, we list several solutions to some common questions that programmers may encounter.

Demo Project 1	*Demo Project 2*	*Demo Project 3*	*Demo Project 4*
			

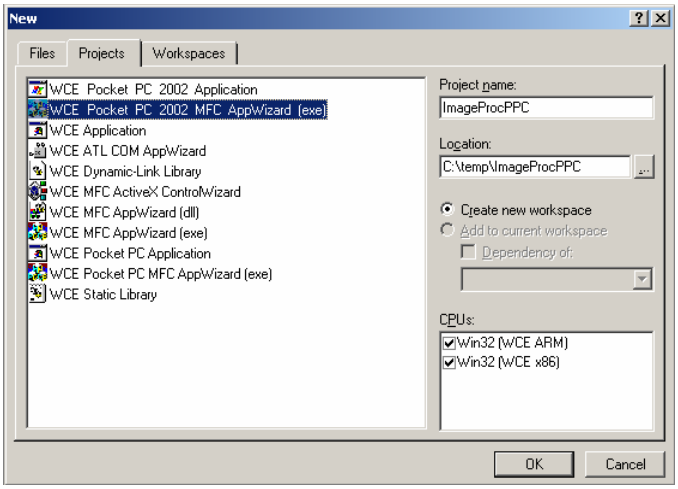
[11] You may want to download Microsoft *eMbedded Visual C++ 4.0* (*Microsoft Windows CE .NET*) from http://msdn.microsoft.com/vstudio/device/datasheet.asp (Release Date: 15 Apr 2002).

[12] *Resources* consist of a wide range of elements, including interface elements, (such as a icon, bitmap, or cursor), customized resources that hold data an application demands, version resources that are used by setup APIs, and menus and dialog boxes. You can add new resources to your project and modify those resources using the resource editor. Most Visual C++ wizards will automatically generate a .rc file for your project.

2. eVC Demo Project-1: Digital Image Processing – Handheld Image Processor

In this demo project, you will design a handheld image processor and learn
(1) how to build a dialog based Application by Microsoft eMbedded Visual C++,
(2) how to install a control (e.g. button) on a dialog box,
(3) how to read a BMP (*InFrame*) file and output another BMP (*OutFrame*) file, and
(4) how to perform digital image processing.

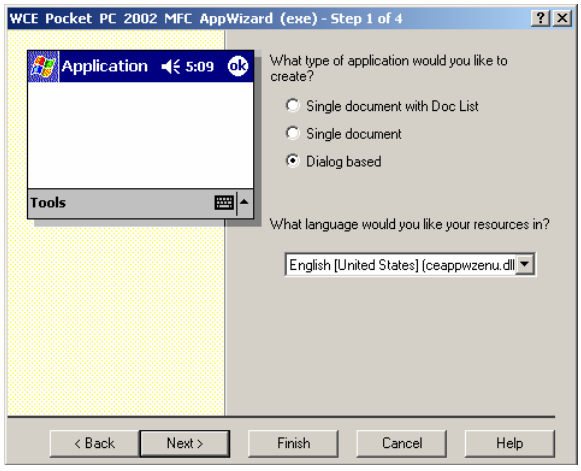
(a) Create a new project by *File* → *New* from eVC menu bar.



(1) Select "*WCE Pocket PC 2002 MFC AppWizard (exe)*" on the *Projects* tap.
(2) Key in "*ImageProcPPC*" on *Project name* edit box and select a *Location* for this project. Also check "*Create new workspace*".
(3) Check "*Win32[WCE ARM]"* and "*Win32[WCE x86]"* on the *CPUs* box[13].
(4) Click "*OK*" and a *WCE Pocket PC 2002 MFC AppWizard* window will pop up.

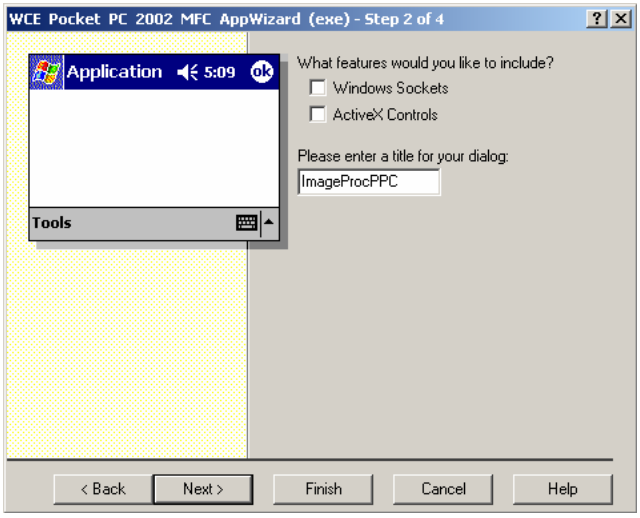
(b) WCE Pocket PC 2002 MFC AppWizard

(1) Choose "*Dialog Based*" and press "*Next*".

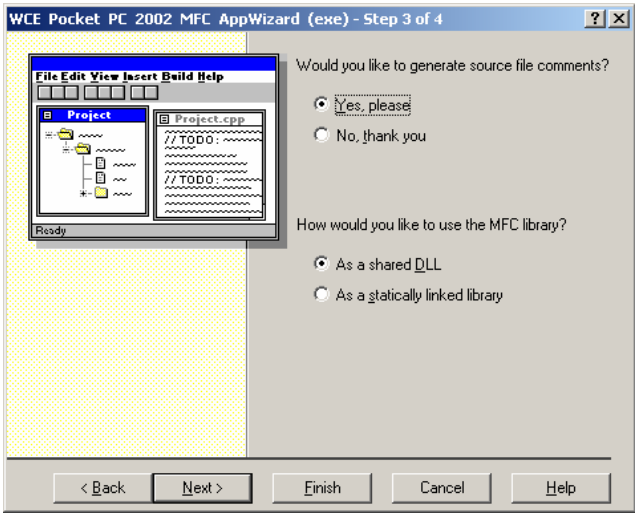


[13] If Pocket PC 2002 SDK is not available, you may create a new project by an older version of MFC AppWizard, such as *WCE MFC AppWizard* or *WCE Pocket PC MFC AppWizard*.

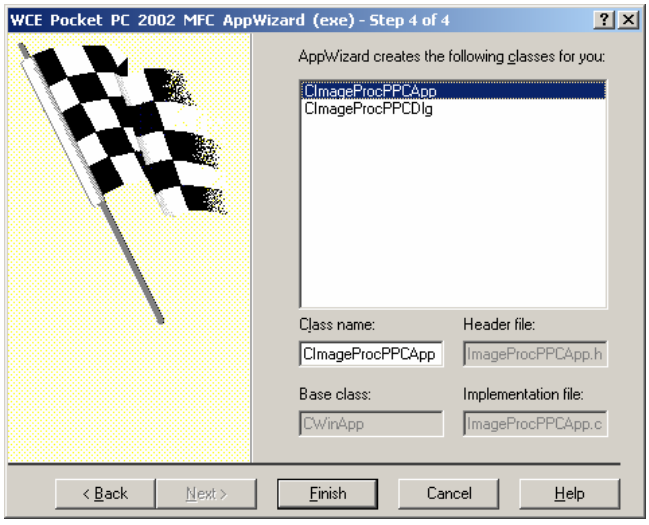
(2) Set title as "*ImageProcPPC*" and disable other check items. Then click "*Next*".



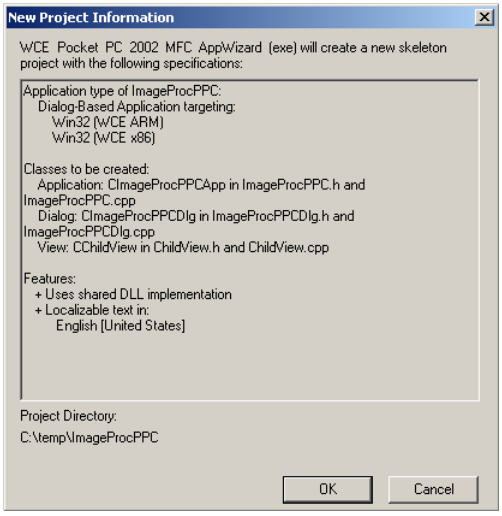
(3) Check "*Yes, please*" and "*As a shared DLL*". Click "*Next*".



(4) Click "*Finish*" to finish the initial setting.

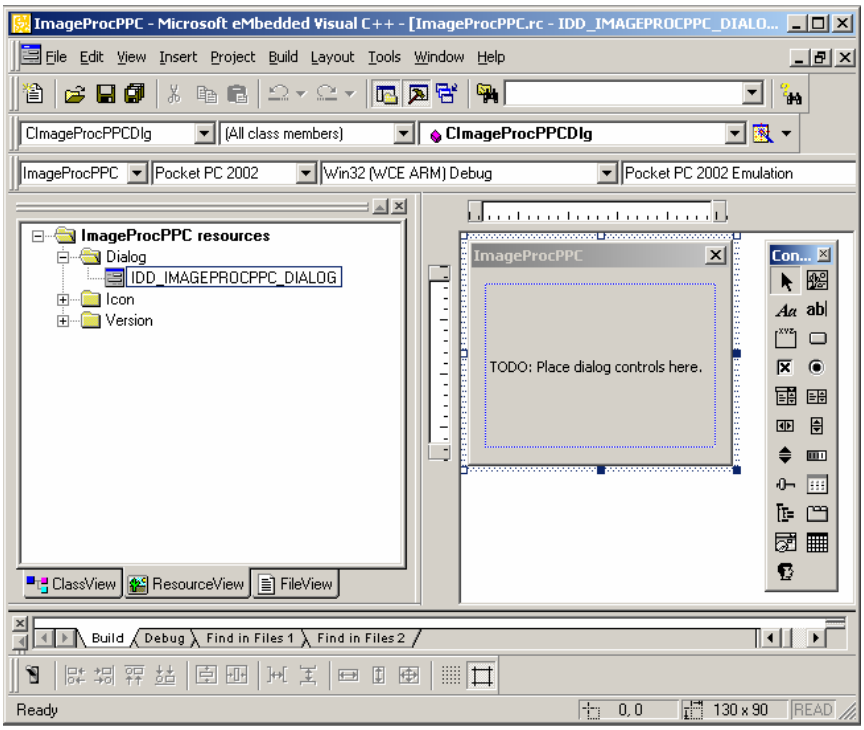


(5) AppWizard will summarize the features and files of new project you created. Click "*OK*" to close the AppWizard.

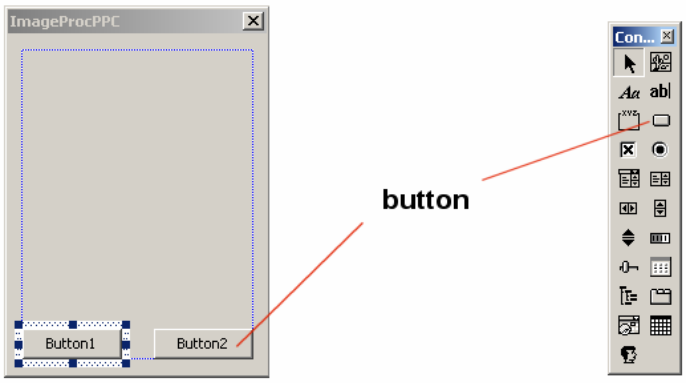

New Project Information
WCE Pocket PC 2002 MFC AppWizard (exe) will create a new skeleton project with the following specifications:
Application type of ImageProcPPC:
Dialog-Based Application targeting:
Win32 (WCE ARM)
Win32 (WCE x86)
Classes to be created:
Application: CImageProcPPCApp in ImageProcPPC.h and ImageProcPPC.cpp
Dialog: CImageProcPPCDlg in ImageProcPPCDlg.h and ImageProcPPCDlg.cpp
View: CChildView in ChildView.h and ChildView.cpp
Features:
+ Uses shared DLL implementation
+ Localizable text in:
English [United States]
Project Directory:
C:\temp\ImageProcPPC
OK
Cancel

(c)Design Dialog Box

(1) Overview: The following figure shows the IDE that we will use in this demo project. Click the *ResourceView* tap in the *Project Workspace Window* and open the *Dialog* folder. You will see *IDD_IMAGEPROCPPC_DIALOG*. Click it and you will see another dialog box with text "*TODO: Place dialog controls here*" shown in the *Edit Window*. We will design our own GUI on this dialog box. The small window to the right of this dialog box is the "*Controls Toolbar*", which provides control components. We will use this toolbar to add controls.



(2) Edit the Dialog Box. Drag and drop two buttons from *Controls toolbar* to the bottom of the dialog box. Adjust the width and height of this dialog box. Also, click the "*TODO: Place dialog controls here*" and delete it.

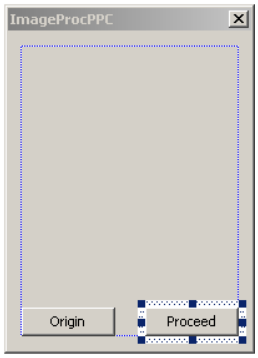


(3) Modify the properties of "*Button1*" and "*Button2*" in the *Push Button Properties* dialog box by right clicking each button and choosing the "*Properties*".

Change *ID* and *Caption* according to the following table.

	Button1	Button2
ID	*IDC_Origin*	*IDC_Proceed*
Caption	*Origin*	*Proceed*

It becomes

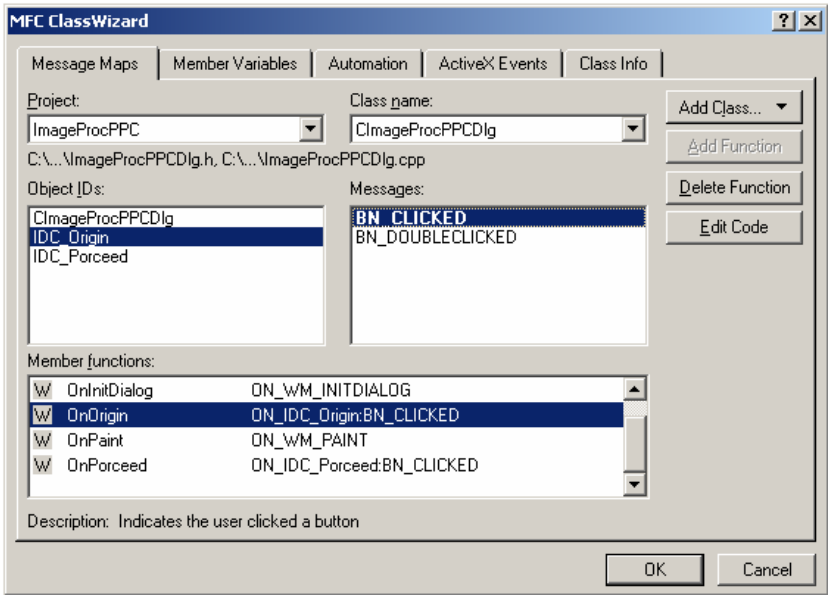


(4) ClassWizard

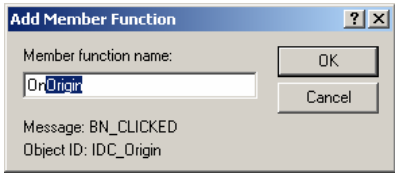
We need to put the messages of controls in a *Message Map*[14]. We can use *ClassWizard* to help us. There are three ways to open *ClassWizard* window. You

[14] Windows is a message-based-event-driven OS. All programs wait (by using a while loop) for any possible inputs, make the judgments, and dispatch to appropriate functions for processing. A *Message Map* associates a handler function with a particular message, command, or notification.

can right click on the dialog box that we are designing and select the *ClassWizard*, or click *View→ ClassWizard* from the eVC menu bar, or *Ctrl-w*. The following dialog window will pop up.



Let's work on the *Origin* button first. Choose *IDC_Origin* in the *Object IDs* window. Double click *BN_CLICKED* in the *Messages* window. An "*Add Member Function*" dialog box will pop up, which is shown in the following figure.

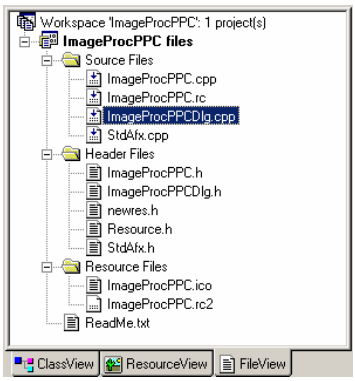


Press "*OK*" to add *OnOgirin* member function. This finishes the message setup for the *Origin* button. There are two more messages we need to establish. Repeat the same procedures described above. The *Object ID*'s, corresponding *Messages*, and *Message Functions* are shown in the following table.

Object ID	**Message**	**Message Function**
CImageProcPPCDlg	*WM_PAINT*	*OnPaint*
IDC_Origin	*BN_CLICKED*	*OnOrigin*
IDC_Proceed	*BN_CLICKED*	*OnProceed*

(d) Add existing files to our project

(1) Click on the *FileView* tap in the *Project Workspace Window*. You will see that WCE Pocket PC 2002 MFC AppWizard has already automatically generated several files, which can be compiled and run, though without any useful functionality. To complete our project, we need to do our own coding.

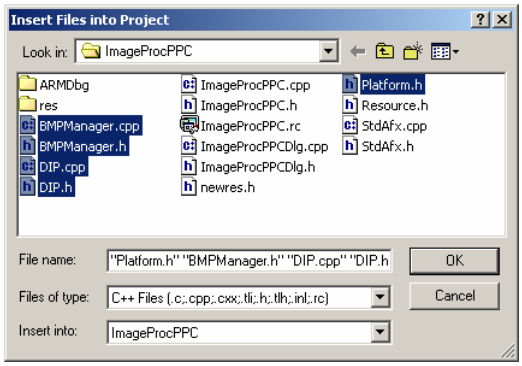


(2) Add existing files to this project.

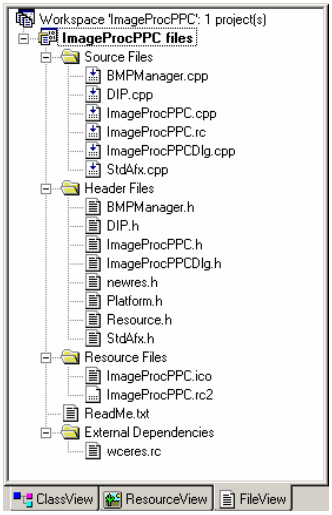
There are several modules already developed by previous 408G groups. Here we use them to save some development time.

(i) Copy and paste the following five files to your current working directory: *BMPManager.cpp*, *BMPManager.h*, *DIP.cpp*, *DIP.h*, and *Platform.h* .[15]

(ii) Click *Project* → *Add to Project* → *Files* from the eVC menu bar.



Add these five files into this project and click *OK*. You will find that the *FileView* becomes the following figure. We can do our own programming now.



[15] These files were modified from the Group 4's final project of ENEE408G Spring 2002 (by Hamed Alaghemand, Hsiu-huei Yen, and Yuan-heng Lo).

(e)Edit *ImageProcPPCDlg.h*[16]

```
// ImageProcPPCDlg.h : header file
//
// Author: Guan-Ming Su
// Date: Aug 2002

#if !defined(AFX_IMAGEPROCPPCDLG_H__D6035EA4_F9E1_4859_9FA9_5E9B7938EA5C__INCLUDED_)
#define AFX_IMAGEPROCPPCDLG_H__D6035EA4_F9E1_4859_9FA9_5E9B7938EA5C__INCLUDED_

#if _MSC_VER >= 1000
#pragma once
#endif // _MSC_VER >= 1000

/////////////////////////////////////////////////////////////////////////////
// CImageProcPPCDlg dialog

class CImageProcPPCDlg : public CDialog
{
// Construction
public:
        CImageProcPPCDlg(CWnd* pParent = NULL);         // standard constructor

// Dialog Data
        //{{AFX_DATA(CImageProcPPCDlg)
        enum { IDD = IDD_IMAGEPROCPPC_DIALOG };
                // NOTE: the ClassWizard will add data members here
        //}}AFX_DATA

        // ClassWizard generated virtual function overrides
        //{{AFX_VIRTUAL(CImageProcPPCDlg)
        protected:
        virtual void DoDataExchange(CDataExchange* pDX);  // DDX/DDV support
        //}}AFX_VIRTUAL

// Implementation
protected:
        HICON m_hIcon;

        // Add your own protected variables and functions here →
        bool DrawOrigin;    // for Origin Button
        bool DrawProceed;   // for Porcess Button
        // ←


        // Generated message map functions
        //{{AFX_MSG(CImageProcPPCDlg)
        virtual BOOL OnInitDialog();
        afx_msg void OnOrigin();
        afx_msg void OnPorceed();
        afx_msg void OnPaint();
        //}}AFX_MSG
        DECLARE_MESSAGE_MAP()
};

//{{AFX_INSERT_LOCATION}}
// Microsoft eMbedded Visual C++ will insert additional declarations immediately before the previous line.

#endif // !defined(AFX_IMAGEPROCPPCDLG_H__D6035EA4_F9E1_4859_9FA9_5E9B7938EA5C__INCLUDED_)
```

[16] Notice that "***// Add your own code →***" and "***//←***" indicates that you may put some codes in these areas. In this example, we use italic red font for the added codes (to distinguish from the codes already automatically generated by eVC).

(f)Edit *ImageProcPPCDlg.cpp*

```
// ImageProcPPCDlg.cpp : implementation file
//
// Author: Guan-Ming Su
// Date: Aug 2002

#include "stdafx.h"
#include "ImageProcPPC.h"
#include "ImageProcPPCDlg.h"

// Add your own .h file →
#include "DIP.h"
// ←

#ifdef _DEBUG
#define new DEBUG_NEW
#undef THIS_FILE
static char THIS_FILE[] = __FILE__;
#endif

/////////////////////////////////////////////////////////////////////////////
// CImageProcPPCDlg dialog

CImageProcPPCDlg::CImageProcPPCDlg(CWnd* pParent /*=NULL*/)
	: CDialog(CImageProcPPCDlg::IDD, pParent)
{
	//{{AFX_DATA_INIT(CImageProcPPCDlg)
		// NOTE: the ClassWizard will add member initialization here
	//}}AFX_DATA_INIT
	// Note that LoadIcon does not require a subsequent DestroyIcon in Win32
	m_hIcon = AfxGetApp()->LoadIcon(IDR_MAINFRAME);

	// Put you codes here (initialization) →
	DrawOrigin = FALSE ;
	DrawProceed = FALSE;
	// ←

}

void CImageProcPPCDlg::DoDataExchange(CDataExchange* pDX)
{
	CDialog::DoDataExchange(pDX);
	//{{AFX_DATA_MAP(CImageProcPPCDlg)
		// NOTE: the ClassWizard will add DDX and DDV calls here
	//}}AFX_DATA_MAP
}

BEGIN_MESSAGE_MAP(CImageProcPPCDlg, CDialog)
	//{{AFX_MSG_MAP(CImageProcPPCDlg)
	ON_BN_CLICKED(IDC_Origin, OnOrigin)
	ON_BN_CLICKED(IDC_Porceed, OnPorceed)
	ON_WM_PAINT()
	//}}AFX_MSG_MAP
END_MESSAGE_MAP()

/////////////////////////////////////////////////////////////////////////////
// CImageProcPPCDlg message handlers

BOOL CImageProcPPCDlg::OnInitDialog()
{
	CDialog::OnInitDialog();

	// Set the icon for this dialog.  The framework does this automatically
	//  when the application's main window is not a dialog
	SetIcon(m_hIcon, TRUE);			// Set big icon
	SetIcon(m_hIcon, FALSE);		// Set small icon
```

```
	CenterWindow(GetDesktopWindow());	// center to the hpc screen

	// TODO: Add extra initialization here

	return TRUE;  // return TRUE  unless you set the focus to a control
}



void CImageProcPPCDlg::OnOrigin()
{
	// TODO: Add your control notification handler code here
	// Add your own code →
	DrawOrigin=TRUE;
	CWnd::RedrawWindow();
	// ←

}

void CImageProcPPCDlg::OnProceed()
{
	// TODO: Add your control notification handler code here
	// Add your own code →
	DrawProceed=TRUE;
	CWnd::RedrawWindow();
	// ←

}

void CImageProcPPCDlg::OnPaint()
{
	CPaintDC dc(this); // device context for painting

	// TODO: Add your message handler code here
	// Add you own code here →
	if(DrawOrigin ) {   // Paint the original Image
	     ShowFrames(this, &dc, ".\\My Documents\\InFrame.BMP");
	     DrawOrigin = FALSE;
	}
	if(DrawProceed ) {    // Do ProcessFrames and Paint the resulted imagea
	      // call function in DIP.cpp
	      ProcessFrames(".\\My Documents\\InFrame.BMP",".\\My Documents\\OutFrame.BMP");
	      ShowFrames(this, &dc, ".\\My Documents\\OutFrame.BMP");
	      DrawProceed = FALSE;
	}
	// ←
	// Do not call CDialog::OnPaint() for painting messages
}
```

(g) Edit *DIP.cpp*

This file deals with the image processing part.

```
// Main function for Digital Image Processing
// ProcessingFrames: you can put your codes to deal with
// ShowFrames: display frame on DialogBox
#include "stdafx.h"
#include <afxwin.h>
#include "BMPMAnager.h"
#include "Platform.h"


// Core Part for Image Processing
void ProcessFrames(char *fileNameIn, char *fileNameOut) {

     TBMPManager mngr;
     TBitmap *bmpProcess;
     bmpProcess=new TBitmap[1];
     pixel *fmIn;      // data structure: typedef struct { byte b; byte g;byte r;} pixel;
     pixel *fmOut;
     word i;
     word pixelNum;     // Number of pixel in an image

    // load frame
    mngr.LoadBMP(fileNameIn, &bmpProcess[0]);
    pixelNum=bmpProcess[0].width*bmpProcess[0].height;
    fmIn=new pixel[pixelNum];
    fmOut=new pixel[pixelNum];
    for(i=0;i<pixelNum;i++) {
          fmIn[i]=bmpProcess[0].data[i];}

   // Image Processing: Input : fmIn ;  Out : fmOut
   // --- Put your code here, each element in fmIn  →
     // example for displaying R component
      for(i=0;i<pixelNum;i++){
               fmOut[i].r=fmIn[i].r;
               fmOut[i].g=0;
               fmOut[i].b=0; }
    // ←

   // output frame
   for(i=0;i<pixelNum;i++) {
         bmpProcess[0].data[i]=fmOut[i];}
         mngr.SaveBMP(fileNameOut, &bmpProcess[0]);

   // clean up memory
   delete[] fmIn;
   delete[] fmOut;
   delete[] bmpProcess;
}


// Show Frame on the screen
void ShowFrames(CWnd *view, CDC* pDC, char *fileName) {
   TBMPManager mngr;
   CBitmap *bmp;
    int lx, ty, sw, sh, w, h;
   CRect rect;
   view->GetClientRect(&rect);
    sw = rect.Width();
    sh = rect.Height();

#ifdef PLATFORM_POCKET_PC
     bmp=mngr.ReadBMPFromFile(fileName);
#else
     bmp=mngr.ReadBMPFromFilePC((LPCTSTR)(fileName));
#endif
```

```
    if(bmp) {
        mngr.GetBitmapDimentions(bmp, w, h);
        lx = rect.left + (sw - w) / 2;
        ty = rect.top + (sh - h) / 2;
        mngr.ShowBitmap(lx, ty, bmp, pDC); }
    else {
        CString title="Error!";
        CString mes="Cannot open file (";
        mes+=fileName;
        mes+=")";
        view->MessageBox((LPCTSTR)mes, (LPCTSTR)title);       }

    delete bmp;
}
```

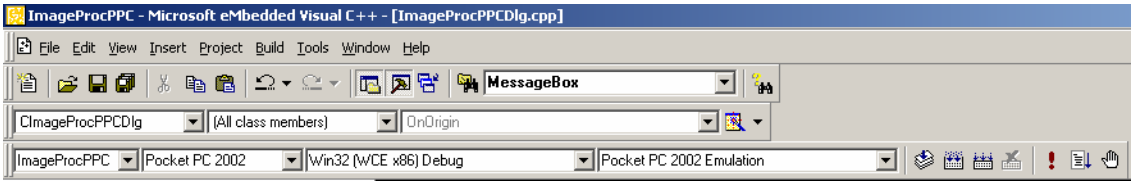
(h) Set *Platform.h*

Remember to add the following line in *Platform*.h so that this file can be run under Pocket PC.

```
#define PLATFORM_POCKET_PC
```

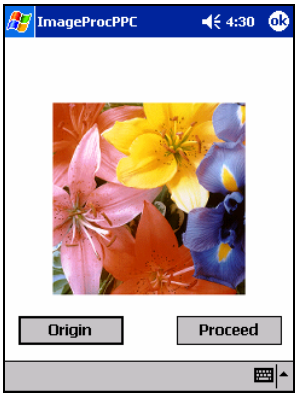
(i) Run your program on the Pocket PC Emulator.

Prepare a 24-bit color BMP file and name it as "*InFrame.BMP*". Transfer this file to the root directory of the Pocket PC emulator or real device [17]. In the eVC IDE, select the *Platform* as *Pocket PC 2002*, *Win32 [WCE x86] Debug*, and *Pocket PC 2002 Emulation*, which is shown as follows.

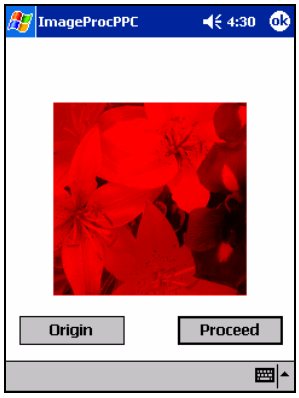


Click the compile icon and then execute icon .

Original Image



Processed Image



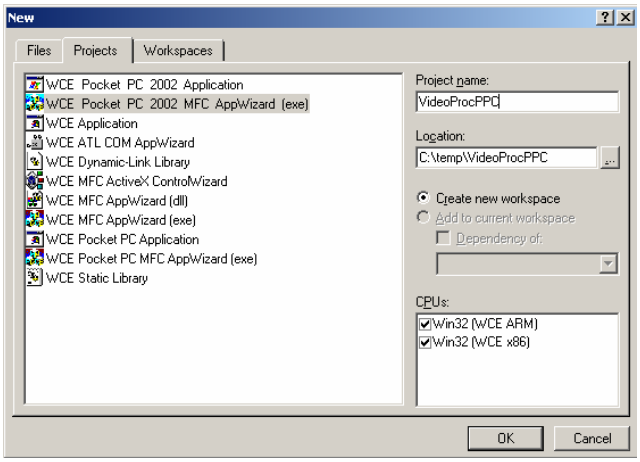
You can also try it on real device by choosing the *Platform* as *Win32 [WCE ARM] Debug* and *Pocket PC 2002 (default device).*

[17] The root directory is one-level higher than the "*My Documents*" directory. Please refer section IV.6.3 for instructions on file transfer.

3. eVC Demo Project-2:Digital Video Processing – Video Player

In this part, we will design a video player and learn
(1) how to build an application with single document by eVC,
(2) how to put RGB data into DIB (Device Independent Bitmap) directly,
(3) how to add List Box, Edit Box, and Slider Control and initialize them, and
(4) how to set a timer to display video periodically.

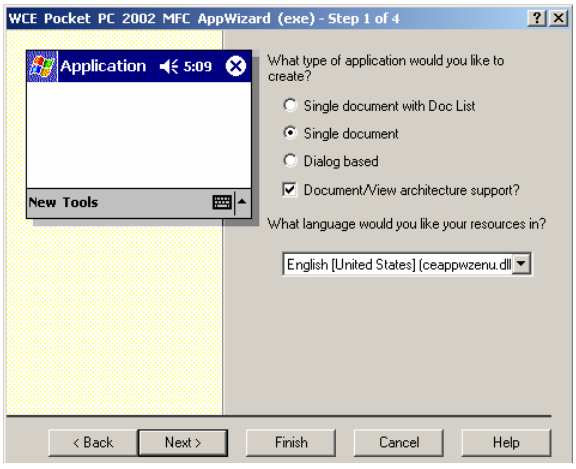
(a) Create a new Project by *File* → *New*



(1) Select "*WCE Pocket PC 2002 MFC AppWizard (exe)*" on the *Projects* tap.
(2) Key in "*VideoProcPPC*" on *Project name* edit box and select a *Location* for this project. Also check "*Create new workspace*".
(3) Check "*Win32[WCE ARM]"* and "*Win32[WCE x86]"* on the *CPUs* box[18].
(4) Click "*OK*" and a *WCE Pocket PC 2002 MFC AppWizard* window will pop up.

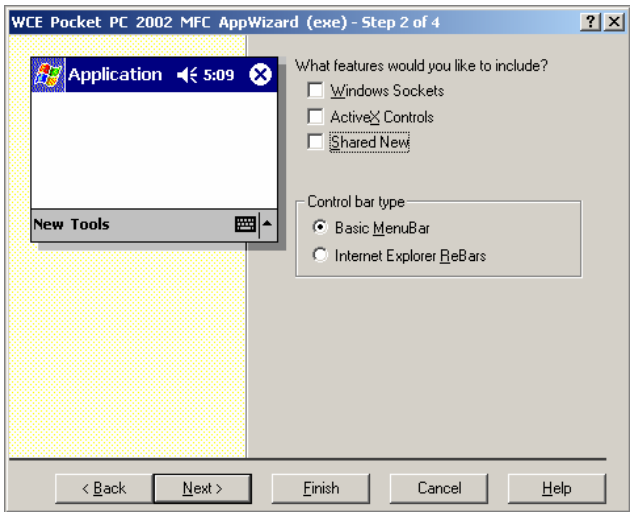
(b) WCE Pocket PC 2002 MFC App Wizard

(1) Choose "*Single document*" and check "*Document/View architecture support*".

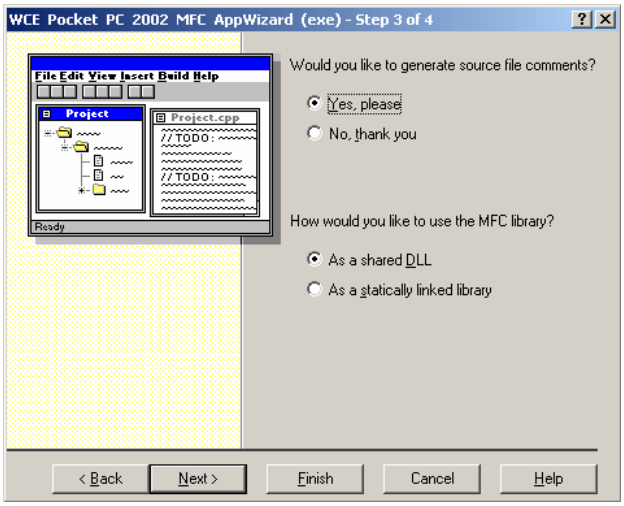


[18] If Pocket PC 2002 SDK is not available, you may create a new project by an older version of MFC AppWizard, such as *WCE MFC AppWizard* or *WCE Pocket PC MFC AppWizard*.

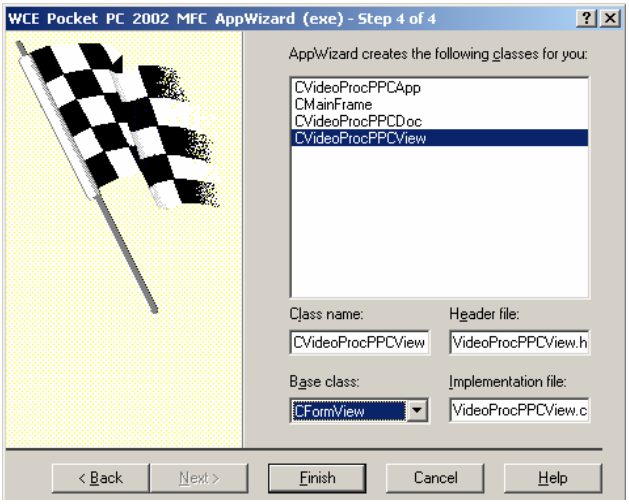
(2) Check "*Basic MenuBar*" on *Control bar type* and disable all features on the top part. Click "*Next*".



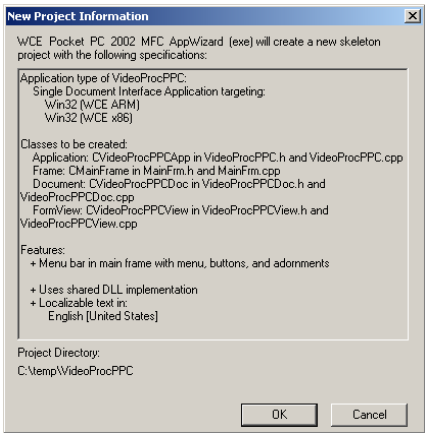
(3) Check "*Yes, please*" and "*As a shared DLL*". Click "*Next*".



(4) Select the *Base Class* of *CVideoProcPPCView* as "*CFormView*". Click "*Finish*".

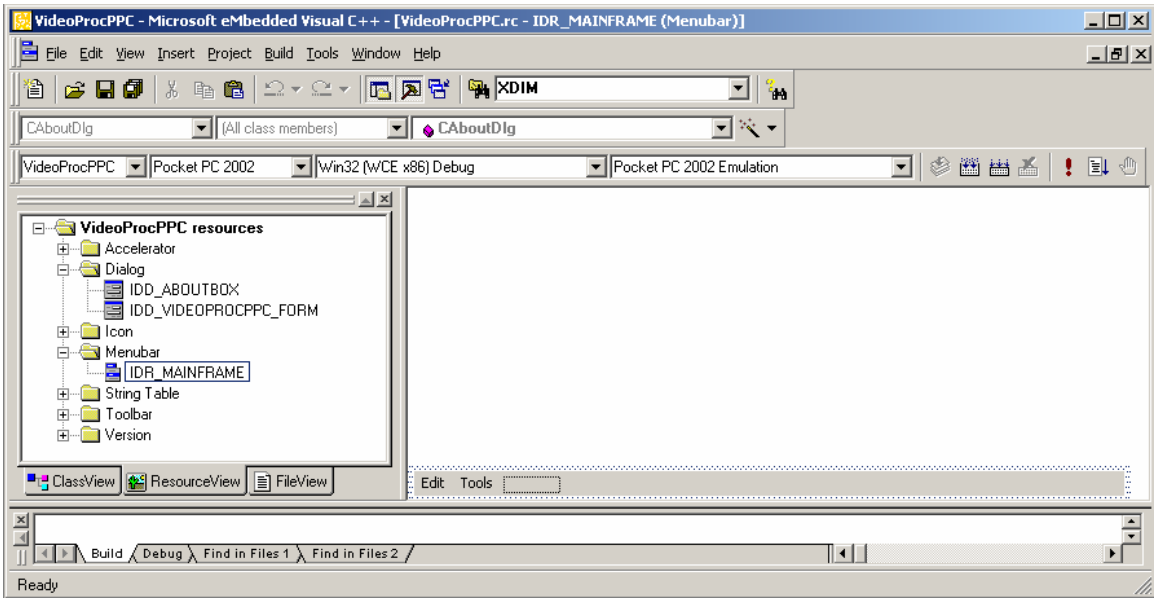


(5) AppWizard will summarize the features and files of the new project you just created. Click "*OK*" to close the AppWizard.

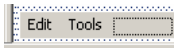

New Project Information
WCE Pocket PC 2002 MFC AppWizard (exe) will create a new skeleton project with the following specifications:
Application type of VideoProcPPC:
Single Document Interface Application targeting:
Win32 (WCE ARM)
Win32 (WCE x86)
Classes to be created:
Application: CVideoProcPPCApp in VideoProcPPC.h and VideoProcPPC.cpp
Frame: CMainFrame in MainFrm.h and MainFrm.cpp
Document: CVideoProcPPCDoc in VideoProcPPCDoc.h and VideoProcPPCDoc.cpp
FormView: CVideoProcPPCView in VideoProcPPCView.h and VideoProcPPCView.cpp
Features:
+ Menu bar in main frame with menu, buttons, and adornments
+ Uses shared DLL implementation
+ Localizable text in:
English [United States]
Project Directory:
C:\temp\VideoProcPPC
OK
Cancel

(c) Edit Menu Bar

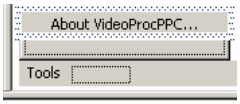
(1) Overview: In this section, we design the GUI of our application program. The figure below shows the IDE that we will use to work on this demo project. Click the *ResourceView* tap in the *Project Workspace Window*.



(2) Double click the *Menubar* on the *ResourceView* tap and then double click *IDR_MAINFRAME*. You will see the menu bar as follows.

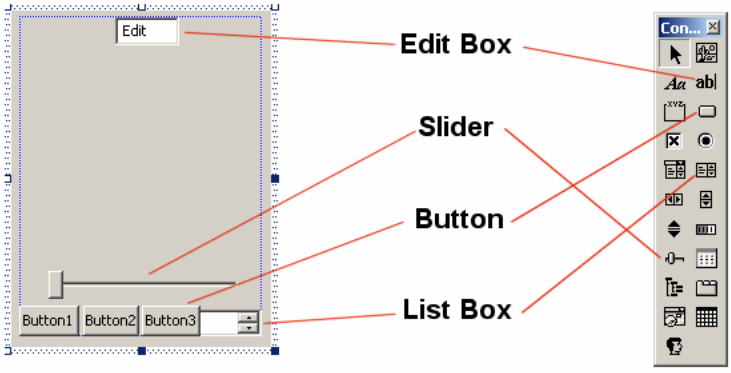


In our application, we do not need any item on the menu bar. Thus, we right click on "*Edit*" and choose "*Cut*". For "*Tools*", we only keep "*About VideoProcPPC*", which can display copyright information, such as your name.



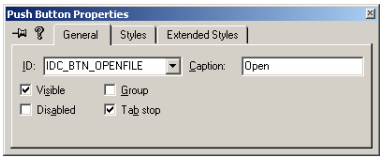
(d) Edit Dialog Box

(1) In this section, we will design a dialog box that provides an interface between Pocket PC and users. Double click *Dialog* on the *ResourceView* tap. Choose *IDD_VIDEOPROCPPC_FORM*. Delete the label "*TODO: Place form controls on this dialog*."



Drag three *Buttons*, one *Edit Box*, one *List Box*, one *Static*, and one *Slider* from *Controls Toolbar* to the dialog box and arrange them as shown in the above figure.

(2) Edit Properties: Right click on each control and choose "*Properties*". A *Control Properties* dialog box will pop up, which is shown in the following figure.

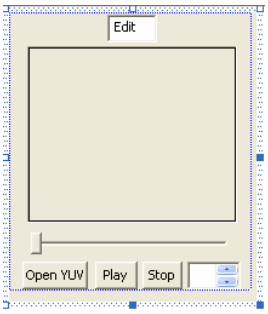


Change the properties of each control according to the following table.

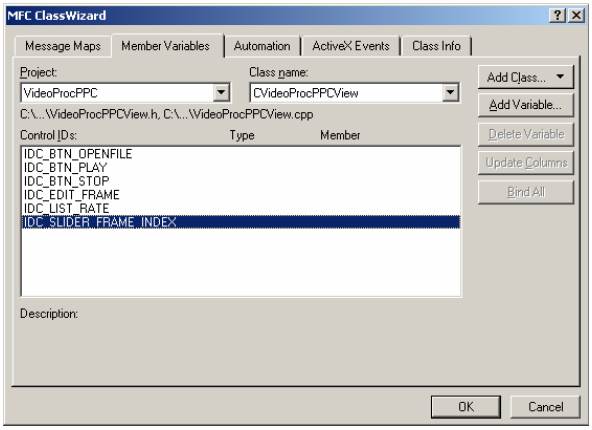
Original Name	**ID**	**Caption**
Button1	*IDC_BTN_OPENFILE*	*Open YUV*
Button2	*IDC_BTN_PLAY*	*Play*
Button3	*IDC_BTN_STOP*	*Stop*
ListBox1	*IDC_LIST_RATE*	
Slider1	*IDC_SLIDER_FRAME_INDEX*	
Edit1	*IDC_EDIT_FRAME*	
Static1	*IDC_STATIC_showBITMAP*	

For "*Static1*" control, choose "Border" item under Styles tab and "*Static Edge*" item under "*Extended Styles*".

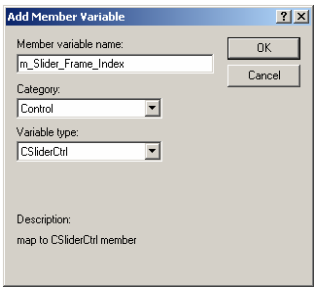
After modification, we will get a dialog box with the following new look.



(3) Initialize the *Slider*, *Edit Box*, and *List Box*: Right click the *Slider* button and click "*ClassWizard*". Click the "*Member Variables*" tap.



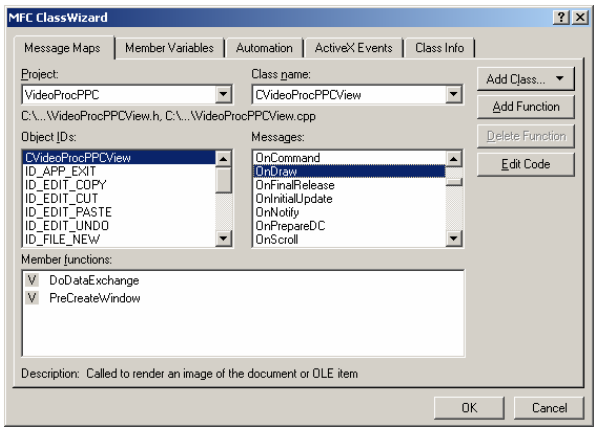
Double click *IDC_SLIDER_FRAME_INDEX* on the *Control IDs* Box. An *Add Member Variable* dialog box will show up.



Type "*m_Slider_Frame_Index*" in the *Member variable name* edit box,. Choose "*Control*" in the *Category* list box and "*CSliderCtrl*" in the *Variable type* list box.

Likewise, for the *List Box*, double click *IDC_LIST_RATE* in the *Control IDs* edit box. Type "*m_List_Rate*" in the *Member variable name* edit box. Choose "*Control*" in the *Category* list box and "*CListBox*" in the *Variable type* list box. For the *Edit Box*, double click *IDC_EDIT_FRAME* in the *Control IDs* edit box. Type "*m_Edit_Frame*" in the *Member variable name* edit box. Choose "*Value*" on the *Category* list box and "*CString*" in *Variable type* list box. For the *Static*, double click *IDC_STATIC_showBITMAP* in the *Control IDs* edit box. Type "*m_showBITMAP*" in the *Member variable name* edit box. Choose "*Control*" on the *Category* list box and "*CStatic*" in *Variable type* list box.

(4) Set Messages and Member Functions



We can add more required messages and member functions using *ClassWizard*, which is shown in the figure above. Make sure the *Project* is set to "*VideoProcPPC*" and *Class name* is "*CViewProcPPCView*".

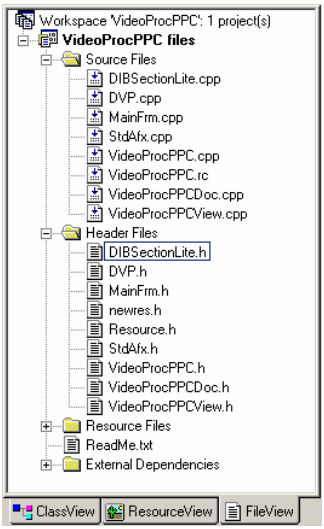
Object ID	**Message**	**Member function**
CVideoProcPPCView	*OnDraw*	*OnDraw*
CVideoProcPPCView	*OnInitialUpdate*	*OnInitialUpdate*
CVideoProcPPCView	*WM_HSCROLL*	*OnHScroll*
CVideoProcPPCView	*WM_TIMER*	*OnTimer*
IDC_BTN_OPENFILE	*BN_CLICKED*	*OnBtnOpenfile*
IDC_BTN_PLAY	*BN_CLICKED*	*OnBtnPlay*
IDC_BTN_STOP	*BN_CLICKED*	*OnBtnStop*
IDC_LIST_RATE	*LBN_DBLCLK*	*OnDblclkListRate*

Set up the messages and member functions of all objects listed in the table above by (i) double clicking *Object IDs*, (ii) double clicking *Messages*, and (iii) adding *Member function* in the *ClassWizard* Window.

(e) Edit *VideoProcPPCDoc.h*

(1) Before we do any further programming, we add some existing codes to this project. Click *Project* → *Add to Project* → *Files* from the eVC menu bar. You will see a dialog box for inserting new files. Add the files *DIBSectionLite.cpp*, *DIBSectionLite.h*, *DVP.cpp*, and *DVP.h* to this project. *DIBSectionLite*[19] deals with the Bitmap, while *DVP* is concerned with video processing. After inserting, the *FileView* tap becomes the figure below.

[19] DIBSectionLite is provided by Chris Maunder. It can be downloaded at http://www.codeproject.com/bitmap/dibsection.asp



(2) Click on *VideoProcPPCDoc.h*[20]

```
// VideoProcPPCDoc.h : interface of the CVideoProcPPCDoc class
// Author : Guan-Ming Su
// Date: Aug 2002
// update: July 5 2003
////////////////////////////////////////////////////////////////////////////

#if !defined(AFX_VIDEOPROCPPCDOC_H__5B9D8AFA_3247_4263_82D7_15053107F9CB__INCLUDED_)
#define AFX_VIDEOPROCPPCDOC_H__5B9D8AFA_3247_4263_82D7_15053107F9CB__INCLUDED_

#if _MSC_VER >= 1000
#pragma once
#endif // _MSC_VER >= 1000

// Put DIBSectionLite.h here →
#include "DIBSectionLite.h"
// ←

class CVideoProcPPCDoc : public CDocument
{
protected: // create from serialization only
	CVideoProcPPCDoc();
	DECLARE_DYNCREATE(CVideoProcPPCDoc)

// Attributes
public:
	// Put your own code here →
	// We add DIBSection as a member of DOC
	CDIBSectionLite m_DIBSection;
	//←

// Operations
public:

// Overrides
	// ClassWizard generated virtual function overrides
	//{{AFX_VIRTUAL(CVideoProcPPCDoc)
	public:
	virtual BOOL OnNewDocument();
```

[20] Notice that "*// **Add your own code** →*" and "*//←*" indicates that you may put some codes in these areas. In this example, we use italic red font for the added codes (to distinguish from the codes already automatically generated by eVC).

```
        virtual void Serialize(CArchive& ar);
        //}}AFX_VIRTUAL

// Implementation
public:
        virtual ~CVideoProcPPCDoc();
#ifdef _DEBUG
        virtual void AssertValid() const;
        virtual void Dump(CDumpContext& dc) const;
#endif

protected:

// Generated message map functions
protected:
        //{{AFX_MSG(CVideoProcPPCDoc)
                // NOTE - the ClassWizard will add and remove member functions here.
                //    DO NOT EDIT what you see in these blocks of generated code !
        //}}AFX_MSG
        DECLARE_MESSAGE_MAP()
};

/////////////////////////////////////////////////////////////////////////////

//{{AFX_INSERT_LOCATION}}
// Microsoft eMbedded Visual C++ will insert additional declarations immediately before the previous line.

#endif // !defined(AFX_VIDEOPROCPPCDOC_H__5B9D8AFA_3247_4263_82D7_15053107F9CB__INCLUDED_)
```

(f) Edit *VideoProcPPCView.h*

```
// VideoProcPPCView.h : interface of the CVideoProcPPCView class
// Author: Guan-Ming Su
// Date: Aug 2002
// update: July 5 2003
/////////////////////////////////////////////////////////////////////////////

#if !defined(AFX_VIDEOPROCPPCVIEW_H__21B7E638_7D17_40EC_85FA_2599C0D7BD34__INCLUDED_)
#define AFX_VIDEOPROCPPCVIEW_H__21B7E638_7D17_40EC_85FA_2599C0D7BD34__INCLUDED_

#if _MSC_VER >= 1000
#pragma once
#endif // _MSC_VER >= 1000

// Put your own include header here →
#include "DIBSectionLite.h"
#include "DVP.h"
//←

class CVideoProcPPCView : public CFormView
{
protected: // create from serialization only
        CVideoProcPPCView();
        DECLARE_DYNCREATE(CVideoProcPPCView)

public:
        //{{AFX_DATA(CVideoProcPPCView)
        enum { IDD = IDD_VIDEOPROCPPC_FORM };
        CStatic      m_showBITMAP;
        CListBox   m_List_Rate;
        CSliderCtrl              m_Slider_Frame_Index;
        CString     m_Edit_Frame;
        //}}AFX_DATA

// Attributes
public:
        CVideoProcPPCDoc* GetDocument();
```

```
// Operations
public:

// Overrides
        // ClassWizard generated virtual function overrides
        //{{AFX_VIRTUAL(CVideoProcPPCView)
        public:
        virtual BOOL PreCreateWindow(CREATESTRUCT& cs);
        virtual void OnInitialUpdate();
        protected:
        virtual void DoDataExchange(CDataExchange* pDX);    // DDX/DDV support
        virtual void OnDraw(CDC* pDC);
        //}}AFX_VIRTUAL

// Implementation
public:
        virtual ~CVideoProcPPCView();
#ifdef _DEBUG
        virtual void AssertValid() const;
        virtual void Dump(CDumpContext& dc) const;
#endif

protected:
        // Put User defined variable here →
        UINT TimerID;       // Timer ID
        UINT TimerStep;     // Timer Step for turn on/off timer
        BYTE* YFrameData;   // memory space for Y data
        BYTE* CbFrameData;              // memory space for Cb data
        BYTE* CrFrameData;  // memory space for Cr data
        FILE *pInputFile;   // File

        BITMAPINFOHEADER bmiHeader;  //Bitmap header infom
        BITMAPINFO bmInfo;          // bitmoap info
        int VideoRate;     // Video refresh rate
        int VideoFormat;   // Video Format,
        int VideoWidth;    // Video width in a frame
        int VideoHeight;   // Video hdight in a frame
        int VideoBytes;    // Total bytes for YUV in a frame
        long int NumFrame;   // total number of frame in a file
        int VideoPixel;     // Total number of pixel in a frame
        int CVideoPixel;    // Number of U(or V) pixel in a frame, for 4:2:0, it's equal to VideoPixel/4
        long int YUVFileOffSet;    // current frame offset in a file
        long int VideoStartIndex;   // current frame index of video for displaying
        int SliderMax;         // Max value of slider
        int SliderMin;         // Min value of slider
       CBitmap *bitmap;       // CBITMAP

        BYTE* dibits;
        // ←

// Generated message map functions
protected:
        //{{AFX_MSG(CVideoProcPPCView)
        afx_msg void OnHScroll(UINT nSBCode, UINT nPos, CScrollBar* pScrollBar);
        afx_msg void OnTimer(UINT nIDEvent);
        afx_msg void OnBtnOpenfile();
        afx_msg void OnBtnPaly();
        afx_msg void OnBtnStop();
        afx_msg void OnDblclkListRate();
        //}}AFX_MSG
        DECLARE_MESSAGE_MAP()
};

#ifndef _DEBUG  // debug version in VideoProcPPCView.cpp
inline CVideoProcPPCDoc* CVideoProcPPCView::GetDocument()
   { return (CVideoProcPPCDoc*)m_pDocument; }
#endif

/////////////////////////////////////////////////////////////////////////////
```

```
//{{AFX_INSERT_LOCATION}}
// Microsoft eMbedded Visual C++ will insert additional declarations immediately before the previous line.

#endif // !defined(AFX_VIDEOPROCPPCVIEW_H__21B7E638_7D17_40EC_85FA_2599C0D7BD34__INCLUDED_)
```

(g) Edit *VideoProcPPCView.cpp*

```
// VideoProcPPCView.cpp : implementation of the CVideoProcPPCView class
// Author: Guan-Ming Su
// Date: Aug 2002
// update: July 5 2003

#include "stdafx.h"
#include "VideoProcPPC.h"

#include "VideoProcPPCDoc.h"
#include "VideoProcPPCView.h"

#ifdef _DEBUG
#define new DEBUG_NEW
#undef THIS_FILE
static char THIS_FILE[] = __FILE__;
#endif

// Put your own include header file here →
#include "DIBSectionLite.h"
#include "DVP.h"

TCHAR filenamein[255]; //has to be here otherwise GetOpenFileName doesn't  work
// ←

/////////////////////////////////////////////////////////////////////////////
// CVideoProcPPCView

IMPLEMENT_DYNCREATE(CVideoProcPPCView, CFormView)

BEGIN_MESSAGE_MAP(CVideoProcPPCView, CFormView)
        //{{AFX_MSG_MAP(CVideoProcPPCView)
        ON_WM_HSCROLL()
        ON_WM_TIMER()
        ON_BN_CLICKED(IDC_BTN_OPENFILE, OnBtnOpenfile)
        ON_BN_CLICKED(IDC_BTN_PALY, OnBtnPaly)
        ON_BN_CLICKED(IDC_BTN_STOP, OnBtnStop)
        ON_LBN_DBLCLK(IDC_LIST_RATE, OnDblclkListRate)
        //}}AFX_MSG_MAP
END_MESSAGE_MAP()

/////////////////////////////////////////////////////////////////////////////
// CVideoProcPPCView construction/destruction

CVideoProcPPCView::CVideoProcPPCView()
        : CFormView(CVideoProcPPCView::IDD)
{
        //{{AFX_DATA_INIT(CVideoProcPPCView)
        m_Edit_Frame = _T("");
        //}}AFX_DATA_INIT
        // TODO: add construction code here

}

CVideoProcPPCView::~CVideoProcPPCView()
{
}

void CVideoProcPPCView::DoDataExchange(CDataExchange* pDX)
{
        CFormView::DoDataExchange(pDX);
        //{{AFX_DATA_MAP(CVideoProcPPCView)
```

```
	DDX_Control(pDX, IDC_LIST_RATE, m_List_Rate);
	DDX_Control(pDX, IDC_SLIDER_FRAME_INDEX, m_Slider_Frame_Index);
	DDX_Text(pDX, IDC_EDIT_FRAME, m_Edit_Frame);
	//}}AFX_DATA_MAP
}

BOOL CVideoProcPPCView::PreCreateWindow(CREATESTRUCT& cs)
{
	// TODO: Modify the Window class or styles here by modifying
	//  the CREATESTRUCT cs

	return CFormView::PreCreateWindow(cs);
}

/////////////////////////////////////////////////////////////////////////////
// CVideoProcPPCView diagnostics

#ifdef _DEBUG
void CVideoProcPPCView::AssertValid() const
{
	CFormView::AssertValid();
}

void CVideoProcPPCView::Dump(CDumpContext& dc) const
{
	CFormView::Dump(dc);
}

CVideoProcPPCDoc* CVideoProcPPCView::GetDocument() // non-debug version is inline
{
	ASSERT(m_pDocument->IsKindOf(RUNTIME_CLASS(CVideoProcPPCDoc)));
	return (CVideoProcPPCDoc*)m_pDocument;
}
#endif //_DEBUG

/////////////////////////////////////////////////////////////////////////////
// CVideoProcPPCView message handlers

void CVideoProcPPCView::OnDraw(CDC* pDC)
{
	// TODO: Add your specialized code here and/or call the base class
	// Put your own code here →
	CVideoProcPPCDoc* pDoc = GetDocument();
	ASSERT_VALID(pDoc);
	CRect rect;
	m_showBITMAP.GetClientRect(&rect);

	int recH, recW, showH, showW;
	recW=rect.Width();		// Calculate Display area
	recH=rect.Height();
	showW=rect.left +(recW-VideoWidth)/2;
	showH=rect.top + (recH-VideoHeight)/2;

	pDoc->m_DIBSection.Draw(pDC, CPoint(showW,showH));
	// ←


}

void CVideoProcPPCView::OnHScroll(UINT nSBCode, UINT nPos, CScrollBar* pScrollBar)
{
	// TODO: Add your message handler code here and/or call default
	// Put your own code here →
	if(nSBCode == SB_THUMBPOSITION){
		YUVFileOffSet=nPos*(VideoPixel+2*CVideoPixel);
		VideoStartIndex=nPos-1;}
	if( NumFrame >0) {
		CVideoProcPPCDoc* pDoc = GetDocument();
```

```
                    ASSERT_VALID(pDoc);
                    CClientDC aDC(&m_showBITMAP);

                    YUVFileOffSet=VideoStartIndex*VideoBytes;
                    pInputFile=_wfopen(filenamein,_T("rb"));  // open file

                    if(pInputFile!=NULL){   //  open file successfully
                              fseek(pInputFile,YUVFileOffSet,SEEK_SET);
                              fread(YFrameData,sizeof(BYTE),VideoPixel,pInputFile);
                              fread(CbFrameData,sizeof(BYTE),CVideoPixel,pInputFile);
                              fread(CrFrameData,sizeof(BYTE),CVideoPixel,pInputFile);
                              fclose(pInputFile); }

                    // Convert YUV(YCbCr) data into RGB (in dibits) by YUV2RGB function in DVP.cpp
                    YUV2RGB(YFrameData,CbFrameData,CrFrameData,dibits,VideoWidth,VideoHeight);
                    pDoc->m_DIBSection.SetBitmap(&bmInfo,dibits);
                    this->OnDraw(&aDC);

                    // Display current frame
                    CString strFrameIndex;
                    strFrameIndex.Format(_T("%d    "),VideoStartIndex);  // convert integer to string
                    _tprintf(_T("%s"), (LPCTSTR) strFrameIndex);
                    m_Edit_Frame=strFrameIndex;
                    UpdateData(FALSE);}
          // ←

          // Disable the default OnHScroll →
          // CFormView::OnHScroll(nSBCode, nPos, pScrollBar);
          // ←
}

void CVideoProcPPCView::OnTimer(UINT nIDEvent)
{
          // TODO: Add your message handler code here and/or call default
          // Put your own code here →
          if (VideoStartIndex>=NumFrame){  // if we reach the last frame, stop displaying
                    TimerStep=0;}
          if( TimerStep==1){     // button Play is clicked
          CVideoProcPPCDoc* pDoc = GetDocument();
                    ASSERT_VALID(pDoc);
                    CClientDC aDC(&m_showBITMAP);

                    if(VideoStartIndex<NumFrame){   // increate frame index
                                        VideoStartIndex=VideoStartIndex+1; }

                    // Display current frame index
                    m_Slider_Frame_Index.SetPos(VideoStartIndex);  // Set slider to current frame index
                    CString strFrameIndex;
                    strFrameIndex.Format(_T("%d    "),VideoStartIndex);  // convert integer to string
                    _tprintf(_T("%s"), (LPCTSTR) strFrameIndex);
                    m_Edit_Frame=strFrameIndex;
                    UpdateData(FALSE);

                    // calculate the current frame position in file
                    YUVFileOffSet=VideoStartIndex*VideoBytes;
                    pInputFile=_wfopen(filenamein,_T("rb"));  // open file

                    if(pInputFile!=NULL){   //  open file successfully
                              fseek(pInputFile,YUVFileOffSet,SEEK_SET);
                              fread(YFrameData,sizeof(BYTE),VideoPixel,pInputFile);
                              fread(CbFrameData,sizeof(BYTE),CVideoPixel,pInputFile);
                              fread(CrFrameData,sizeof(BYTE),CVideoPixel,pInputFile);
                              fclose(pInputFile); }

                    // Convert YUV(YCbCr) data into RGB (in dibits) by YUV2RGB function in DVP.cpp
                    YUV2RGB(YFrameData,CbFrameData,CrFrameData,dibits,VideoWidth,VideoHeight);

                    // Set Bitmap
```

```
                    pDoc->m_DIBSection.SetBitmap(&bmInfo,dibits);
                    this->OnDraw(&aDC);                         }
            else{           // Button Stop is pressed
                    TimerStep = 0;
                    KillTimer(TimerID); }
            // ←

            CFormView::OnTimer(nIDEvent);
}

void CVideoProcPPCView::OnBtnOpenfile()
{
            // TODO: Add your control notification handler code here
            // Put your own code here →
            FILE *pInputFile;
            OPENFILENAME ofn;

            TimerStep=0;
            VideoStartIndex=0;  // initial start display frame index
            memset(&ofn,0,sizeof(ofn));
            ofn.lStructSize=sizeof(ofn);
            ofn.lpstrFile=filenamein;
            ofn.nMaxFile=255;
            ofn.lpstrFilter=_T("Vidio Files:*.yuv\0*.yuv\0All Files:*.*\0*.*\0\0");
            ofn.lpstrInitialDir=NULL;
            if(GetOpenFileName(&ofn)==TRUE) {   // if successfully get open file name
                    pInputFile=_wfopen(filenamein,_T("rb"));  // open file
                    if(pInputFile!=NULL){   //  open file successfully
                            fseek(pInputFile,0,SEEK_END);
                            long int lastPos;
                            lastPos=ftell(pInputFile);
                            NumFrame=lastPos/VideoBytes;  // Calculate Number of frame in this file
                            fclose(pInputFile);
                            m_Slider_Frame_Index.SetRangeMin(1,FALSE);  // reset slider max and min
            m_Slider_Frame_Index.SetRangeMax(NumFrame,FALSE);
                UpdateData(FALSE);                          }
                    else{       MessageBox(_T("Cannot Open File"),MB_OK);} } // fail to open file
            else{ MessageBox(_T("Cannot Get Open File Name"),MB_OK); }
            // ←

}

void CVideoProcPPCView::OnBtnPaly()
{
            // TODO: Add your control notification handler code here
            // Put your own code here →
           int interval ;
            if(NumFrame >0 ){
                    interval= 1000/VideoRate;
                    TimerID = SetTimer(99, interval, NULL);
                    TimerStep = 1;}
             // ←

}

void CVideoProcPPCView::OnBtnStop()
{
            // TODO: Add your control notification handler code here
            // Put your own code here →
            TimerStep=0;            // stop timer
            // ←

}

void CVideoProcPPCView::OnDblclkListRate()
{
```

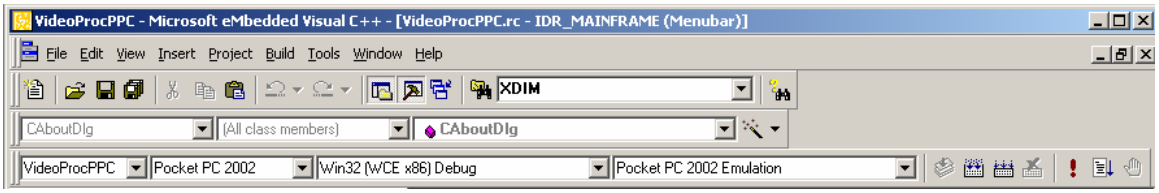
```
	// TODO: Add your control notification handler code here
	// Puy your own code here →
	int nCount;
	nCount=m_List_Rate.GetCurSel();

	TimerStep=0;   // stop timer
	switch(nCount){
		case 0:
			VideoRate=1; break;
		case 1:
			VideoRate=5; break;
		case 2:
			VideoRate=10; break;
		case 3:
			VideoRate=20; break;
		case 4:
			VideoRate=24; break;
		default:
			VideoRate=30;
			break;}
	// ←
}

void CVideoProcPPCView::OnInitialUpdate()
{
	CFormView::OnInitialUpdate();

	// TODO: Add your specialized code here and/or call the base class
	// Put your initialization here →
	// Initialize video parameters
	VideoFormat=0;      // initial format is QCIF
	VideoRate=30;       // initial rate is 30 frame per second
	VideoWidth=176;     // initial width of video for QCIF
	VideoHeight=144;    // initial height of video for QCIF
	VideoStartIndex=0;  // initial start display frame index
	VideoPixel=(int)(VideoWidth*VideoHeight);
	CVideoPixel=VideoPixel/4;
	VideoBytes=VideoPixel+2*CVideoPixel;
	YUVFileOffSet=0;
	TimerStep=0;

	// initial working space for BITMAP
	dibits=new BYTE[3*VideoPixel];

	// Initialize Y Cb Cr memory space
	YFrameData=new BYTE[VideoPixel];
	CbFrameData=new BYTE[CVideoPixel];
	CrFrameData=new BYTE[CVideoPixel];

	// Initialize Controller
	m_Slider_Frame_Index.SetRangeMin(1,FALSE);  // set min tick on slider
	m_Slider_Frame_Index.SetRangeMax(100,FALSE);  // set max tick on slider
	m_List_Rate.AddString(_T("01"));   // add string on list box
	m_List_Rate.AddString(_T("05"));
	m_List_Rate.AddString(_T("10"));
	m_List_Rate.AddString(_T("20"));
	m_List_Rate.AddString(_T("24"));
	m_List_Rate.AddString(_T("30"));
	m_List_Rate.SetCurSel(4);
	m_Edit_Frame=_T("0");           // set edit box caption as "0"
	UpdateData(FALSE);     // update controller

	// Initialize Bitmap header as 24 bits true color
	bitmap=new CBitmap();
	bmiHeader.biSize =sizeof(BITMAPINFOHEADER);
	bmiHeader.biWidth = VideoWidth;
	bmiHeader.biHeight = VideoHeight;
	bmiHeader.biPlanes = 1;;
```

```
            bmiHeader.biBitCount =24;
            bmiHeader.biCompression= BI_RGB;;
            bmiHeader.biSizeImage= 3*VideoPixel;
             bmiHeader.biClrUsed = 16777216;
             bmiHeader.biClrImportant = 16777216;
             bmInfo.bmiHeader=bmiHeader;
            // ←
}
```

When compiling, some error messages on precompiled header may show up. Please refer to section IV.6.1 for solutions.

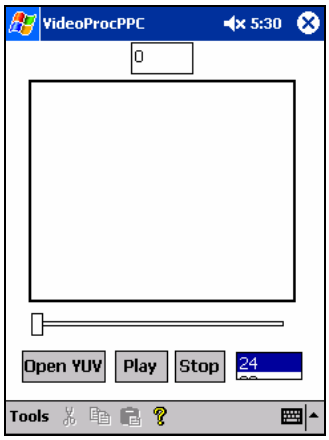
(i) Run your program on the emulator:

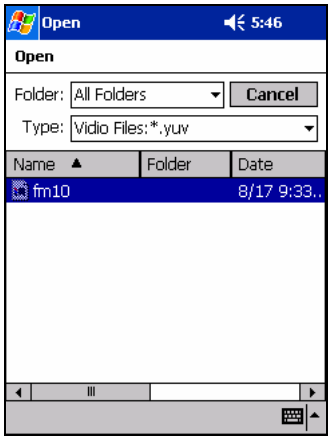
In the eVC IDE, select the Platform as *Pocket PC 2002*, *Win32 [WCE x86] Debug*, and *Pocket PC 2002 Emulation*, which is shown in the figure below.



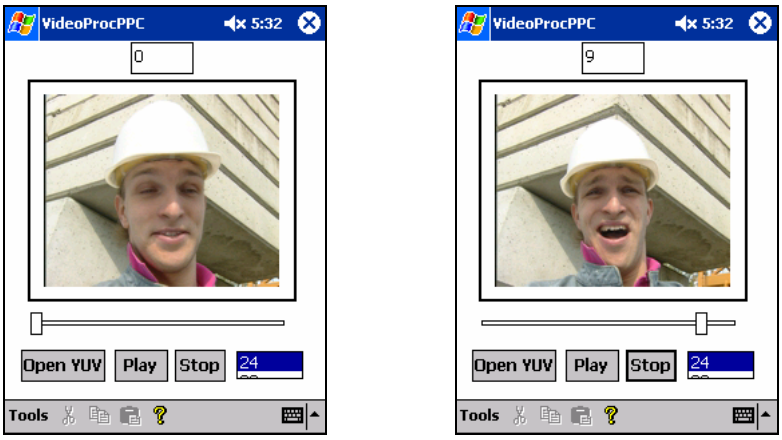
Compile you program by clicking and run it by clicking .

You will see an interface shown in the left figure below. Click the "*Open YUV*" button, and an *Open File Window* will pop up. Let's select one YUV file.



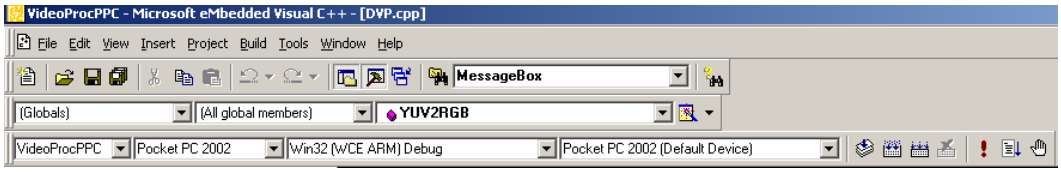


Click the "*Play*" button to play a video or drag "*Slider*" to any position to randomly access this video. Also, you can change the value in the "*Rate*" list box to slow down the video.



(j) Run your program on the Pocket PC[21]

You can to compile and run this program in the real device. From the eVC IDE, choose Platform as *Pocket PC 2002*, *Win32[WCE ARM] Debug*, and *Pocket PC 2002[Default Device]*. Then click the compile and execute buttons. Enjoy your new pocket video player.

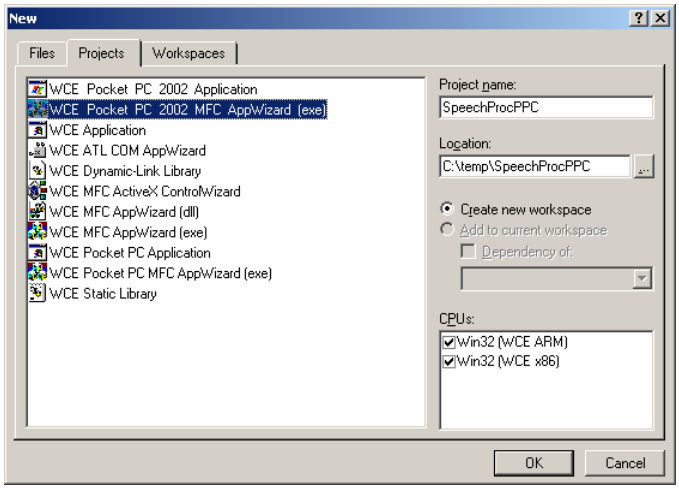


[21] This demo project is not optimized for real Pocket PC. You will observe that the refresh rate of video is slow.

4. eVC Demo Project-3:Digital Speech Processing – Spectrum Analyzer

In this demo project, you will design a spectrum analyzer and learn
(1) how to load, save, and record a wave file and,
(2) how to design a Menu Bar and Open File Window dialog box,
(3) how to draw data on screen, and
(4) how to perform digital speech processing, such as Fast Fourier Transform.

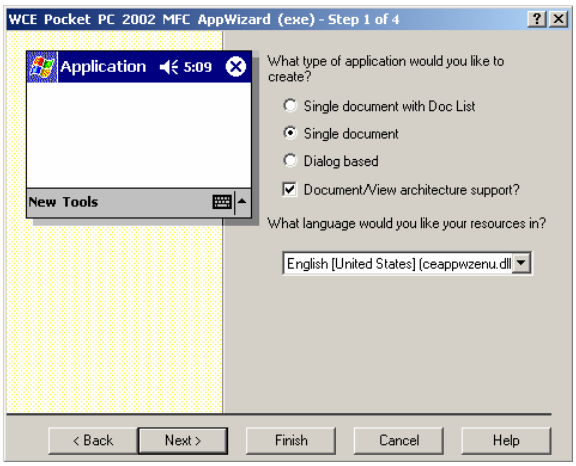
(a) Create a new Project by *File* → *New*



(1) Select "*WCE Pocket PC 2002 MFC AppWizard (exe)*" on the *Projects* tap
(2) Key in "*AudioProcPPC*" on *Project name* edit box and select a *Location* for this project. Also check "*Create new workspace*".
(3) Check "*Win32[WCE ARM]"* and "*Win32[WCE x86]"* on the *CPUs* box[22]
(4) Click "*OK*" and a *WCE Pocket PC 2002 MFC AppWizard* window will pop up.

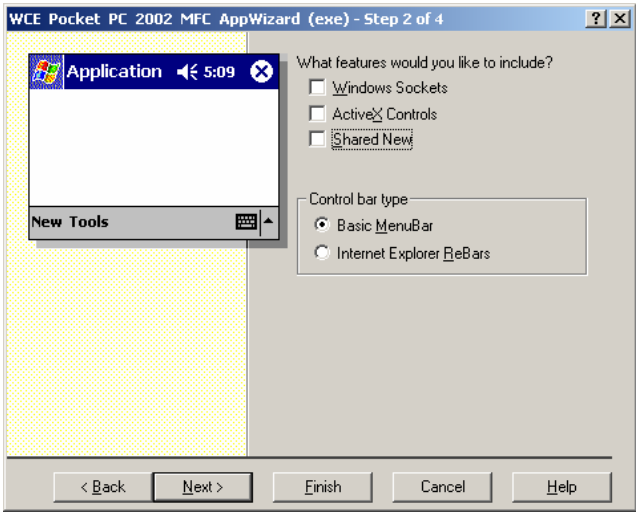
(b)WCE Pocket PC 2002 MFC AppWizard

(1) Choose "*Single document*" and check "*Document/View architecture support*".

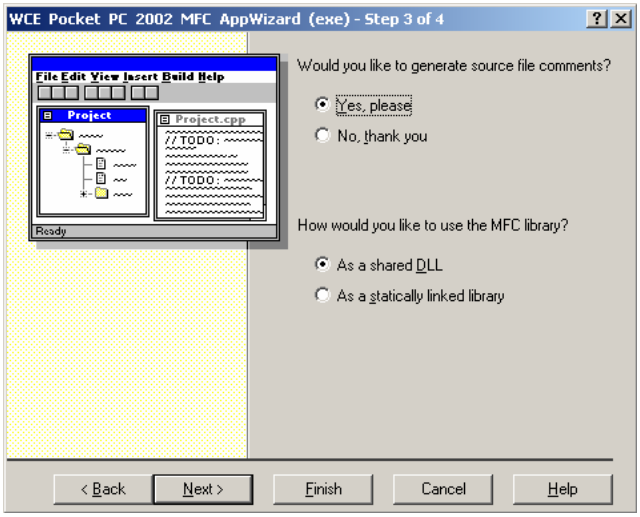


[22] If Pocket PC 2002 SDK is not available, you may create a new project by an older version of MFC AppWizard, such as *WCE MFC AppWizard* or *WCE Pocket PC MFC AppWizard*.

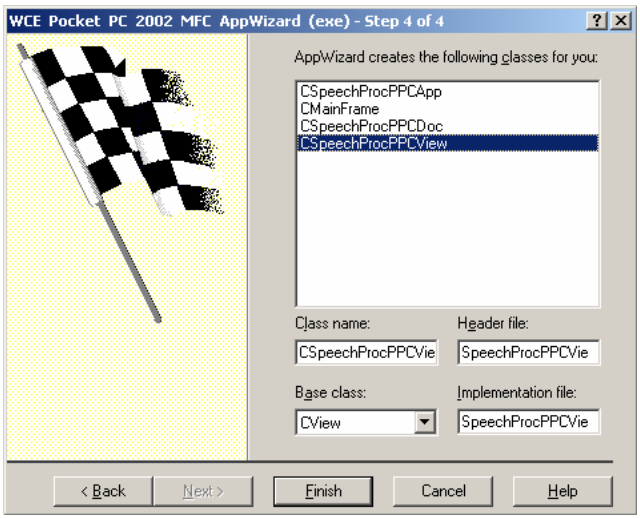
(2) Disable all features and choose "*Basic MenuBar*" on *Control bar type*.



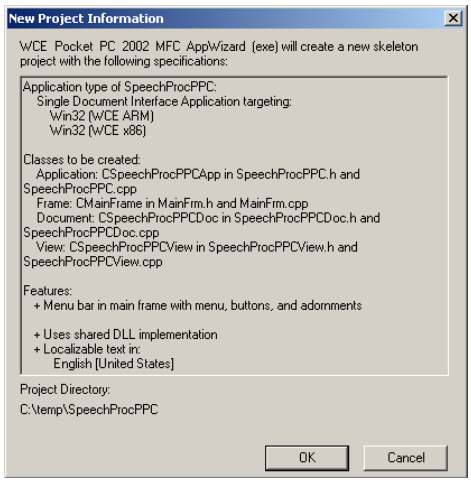
(c) Choose "*generate source file comments*" and "*As a shared DLL*". Click "*Next*".



(d) Select the *Base class* of *CSpeechProcPPCView* as *CView*. Click "*Finish*".

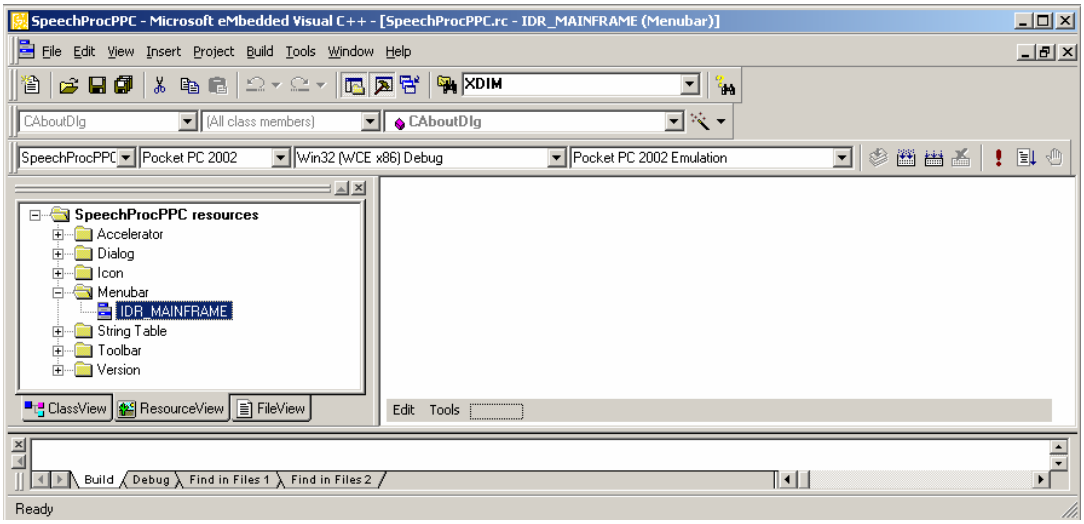


(g) AppWizard will summarize the features and files of new project you created. Click "OK" to close the AppWizard.


New Project Information
WCE Pocket PC 2002 MFC AppWizard (exe) will create a new skeleton project with the following specifications:
Application type of SpeechProcPPC:
Single Document Interface Application targeting:
Win32 (WCE ARM)
Win32 (WCE x86)
Classes to be created:
Application: CSpeechProcPPCApp in SpeechProcPPC.h and SpeechProcPPC.cpp
Frame: CMainFrame in MainFrm.h and MainFrm.cpp
Document: CSpeechProcPPCDoc in SpeechProcPPCDoc.h and SpeechProcPPCDoc.cpp
View: CSpeechProcPPCView in SpeechProcPPCView.h and SpeechProcPPCView.cpp
Features:
+ Menu bar in main frame with menu, buttons, and adornments
+ Uses shared DLL implementation
+ Localizable text in:
English [United States]
Project Directory:
C:\temp\SpeechProcPPC
OK
Cancel

(c) Edit Menu

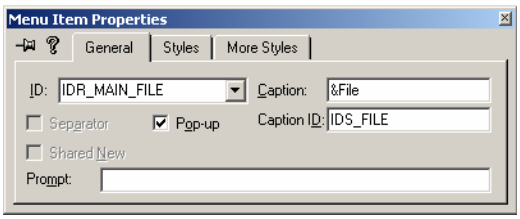
(1) Overview: The following figure shows the IDE we will use in this demo project. Click the *ResourceView* tap in the IDE.



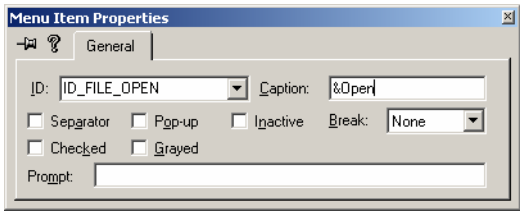
(2) Design *Menu*

Double click *IDR_MAINFRAME* under *Menubar* in the *ResourceView* tap. A default menu will show up in the *Edit Window*.

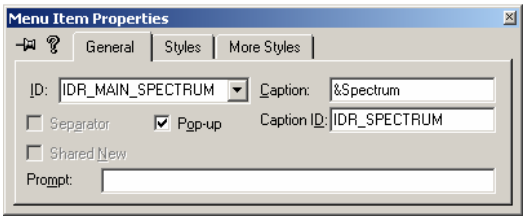
We do not need "*Edit*", thus, right click it and cut it. For "*Tools*", we only reserve "*About SpeechProcPPC*". We will create two main items on the menu bar. One is "*File*" and the other is "*Spectrum*". Let's work on "*File*" first. You can click the dashed rectangular and a *Menu Item Properties* dialog box will pop up, which is shown in the following figure. Change *ID* into "*IDR_MAIN_FILE"*, *Caption* into "*&File*", ("*&F*" means that you can press "*Alt*" and "*F*" to access this item), and *Caption ID* into "*IDS_FILE"*.



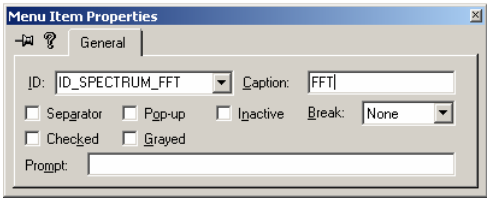
So far, we have already created the *File* main menu item. We need to add four sub items, *Open File*, *Save File*, *Record Start* and *Record Stop*, under this main menu item. Let's work on the first item, *Open File*. Right click the dashed rectangular above the *File* menu item and choose "*Properties*". You will see another dialog box shown below. Modify *ID* as *ID_FILE_OPEN* and *Caption* as "*&Open*". Make the other three items by the same procedures. Set *ID* (*Caption*) for *Save File*, *Record Start*, and *Record Stop* as *ID_FILE_SAVE* (*&Save*), *ID_FILE_StartRecord* (*REC start*), and *ID_FILE_StopRecord* (*REC Stop*), respectively. We finish the design of the first main menu item.



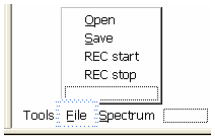
Repeat the same procedures described above to create *Spectrum* main menu item. Set its properties according to the following figure.

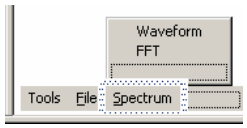


For the functionality of plotting waveform and FFT, we need to add two sub-items under this *Spectrum* item. Double click the dashed rectangular box that is above *Spectrum*, another *Menu Item Properties* dialog box will pop up.



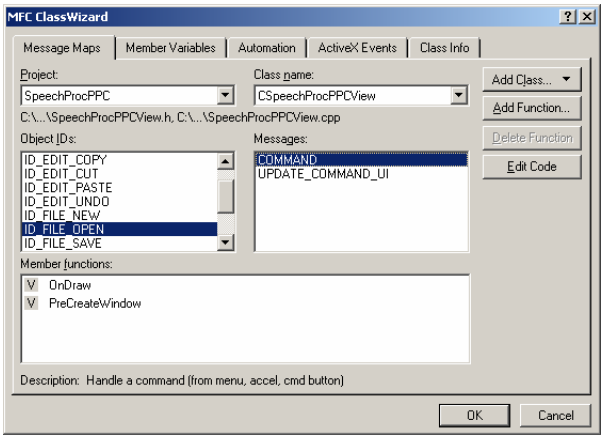
You can create two new sub-items whose *ID* are *ID_SPECTRUM_WAVEFORM* and *ID_SPECTRUM_FFT*, respectively, *Caption* are "*Waveform*" and "*FFT*", respectively. Finally, the menu becomes the following figure.



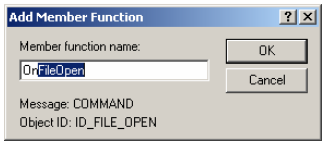


(3) Set *Message*

After setting up the menu bar, we need to add messages and their corresponding reactions if users click those items. We can use *ClassWizard* (from *View* → *ClassWizard* in eVC IDE) to edit the messages in Windows.



Make sure the "*Class name*" is set to "*CSpeechProcPPCView*". Double click "*ID_FILE_OPEN"* in the *Object IDs* box and "*COMMAND*" in the *Messages* box. An "*Add Member Function*" dialog box will show up. Press "*OK*".

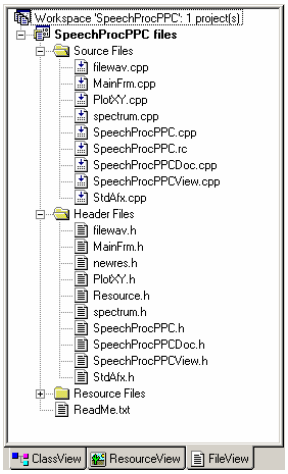


Repeat the same procedure for other five objects whose *Object ID* are *ID_FILE_SAVE*, *ID_FILE_StartRecord*, and *ID_FILE_StopRecord*, *ID_SPECTRUM_WAVEFORM* and *ID_SPECTRUM_FFT*, respectively. Now, we already set up the GUI and messages. It's time to move to programming part.

(d)Edit *SpeechProcPPCView.h*

(1) Before we do any further programming, we add some existing codes to this project. From *Project* → *Add to Project*→ *Files* in the eVC IDE, add the files *PloyXY.cpp*, *PlotXY.h*, *filewav.cpp*, *filewav.h*[23], *spectrum.cpp*, and *spectrum.h*. Make sure they are already put in the working directory. Files *PlotXY* draws 2-D figures, files *filewav* are concerned with reading and writing .wav files, and files *spectrum* implement the Fast Fourier Transform algorithm. After inserting, you can check those files on the *FileView* tap.

[23] *filewav.cpp* and *filewav.h* are provided by Andres Kwasinski.



(2) We add some variables used in this project in the header file[24].

```
// SpeechProcPPCView.h : interface of the CSpeechProcPPCView class
// Author: Guan-Ming Su
// Date: Aug 2002
////////////////////////////////////////////////////////////////////////////

#if !defined(AFX_SPEECHPROCPPCVIEW_H__F7F6832F_7040_4812_BAB5_3290253E43EE__INCLUDED_)
#define AFX_SPEECHPROCPPCVIEW_H__F7F6832F_7040_4812_BAB5_3290253E43EE__INCLUDED_

#if _MSC_VER >= 1000
#pragma once
#endif // _MSC_VER >= 1000


class CSpeechProcPPCView : public CView
{
protected: // create from serialization only
        CSpeechProcPPCView();
        DECLARE_DYNCREATE(CSpeechProcPPCView)

// Attributes
public:
        CSpeechProcPPCDoc* GetDocument();

// Operations
public:

// Overrides
        // ClassWizard generated virtual function overrides
        //{{AFX_VIRTUAL(CSpeechProcPPCView)
        public:
        virtual void OnDraw(CDC* pDC);  // overridden to draw this view
        virtual BOOL PreCreateWindow(CREATESTRUCT& cs);
        protected:
        //}}AFX_VIRTUAL

// Implementation
public:
        virtual ~CSpeechProcPPCView();
#ifdef _DEBUG
        virtual void AssertValid() const;
        virtual void Dump(CDumpContext& dc) const;
#endif
```

[24] Notice that "***// Add your own code →***" and "***//←***" indicates that you may put some codes in these areas. In this example, we use italic red font for the added codes (to distinguish from the codes already automatically generated by eVC).

```
protected:
    // Put your own protected data here →
        int show_spectrum_type;    // display type of figure
        long int NumSample;        // number of sample
        int* Sample;               // sample data
        int FigureWidth;           // width of figure
        int FigureHeight;          // height of figure
        bool m_bOneFileExist;                       // indicator for a existing file in application

        MMRESULT mr;                                // return value for access WAVE function
        HWAVEIN hWaveIn;                // handel for microphone input
        WAVEHDR MICbuffer;                          // buffer for microphone input
        WAVEFORMATEX RecordWavFileFmt;    //   Defines the format of waveform audio data.
    //←

// Generated message map functions
protected:
        //{{AFX_MSG(CSpeechProcPPCView)
        afx_msg void OnFileOpen();
        afx_msg void OnFileSave();
        afx_msg void OnFILEStartRecord();
        afx_msg void OnFILEStopRecord();
        afx_msg void OnSpectrumFft();
        afx_msg void OnSpectrumWaveform();
        //}}AFX_MSG
        DECLARE_MESSAGE_MAP()
};

#ifndef _DEBUG  // debug version in SpeechProcPPCView.cpp
inline CSpeechProcPPCDoc* CSpeechProcPPCView::GetDocument()
   { return (CSpeechProcPPCDoc*)m_pDocument; }
#endif

/////////////////////////////////////////////////////////////////////////////

//{{AFX_INSERT_LOCATION}}
// Microsoft eMbedded Visual C++ will insert additional declarations immediately before the previous line.

#endif // !defined(AFX_SPEECHPROCPPCVIEW_H__F7F6832F_7040_4812_BAB5_3290253E43EE__INCLUDED_)
```

(e)Edit *SpeechProcPPCView.cpp*

Modify *SpeechProcPPCView.cpp* by following the table below.

```
// SpeechProcPPCView.cpp : implementation of the CSpeechProcPPCView class
//
// Author: Guan-Ming Su
// History:  Aug 2002  v1..0
//           7/6/2003 :  v1.1    1. Support Save a wave file : WriteWav
//                               2. Fix the starting point coodinate in DrawXY
//                               3. Add recoding funtionality

#include "stdafx.h"
#include "SpeechProcPPC.h"

#include "SpeechProcPPCDoc.h"
#include "SpeechProcPPCView.h"

#ifdef _DEBUG
#define new DEBUG_NEW
#undef THIS_FILE
static char THIS_FILE[] = __FILE__;
#endif

// Put your include header file here →
#include <math.h>
#include <mmreg.h>
```

```
#include "PlotXY.h"
#include "filewav.h"
#include "spectrum.h"
// ## IMPORTANT! It has to be here otherwise GetOpenFileName doesn't  work
TCHAR in_filename[255];
TCHAR out_filename[255];
// ←

//////////////////////////////////////////////////////////////////////////
// CSpeechProcPPCView

IMPLEMENT_DYNCREATE(CSpeechProcPPCView, CView)

BEGIN_MESSAGE_MAP(CSpeechProcPPCView, CView)
        //{{AFX_MSG_MAP(CSpeechProcPPCView)
        ON_COMMAND(ID_FILE_OPEN, OnFileOpen)
        ON_COMMAND(ID_FILE_SAVE, OnFileSave)
        ON_COMMAND(ID_FILE_StartRecord, OnFILEStartRecord)
        ON_COMMAND(ID_FILE_StopRecord, OnFILEStopRecord)
        ON_COMMAND(ID_SPECTRUM_FFT, OnSpectrumFft)
        ON_COMMAND(ID_SPECTRUM_WAVEFORM, OnSpectrumWaveform)
        //}}AFX_MSG_MAP
END_MESSAGE_MAP()

//////////////////////////////////////////////////////////////////////////
// CSpeechProcPPCView construction/destruction

CSpeechProcPPCView::CSpeechProcPPCView()
{
        // TODO: add construction code here
        // Put your initial setting here →
        // for recoring buffer
        MICbuffer.lpData = new char[64000];             //char for mono recording, short int
        MICbuffer.dwBufferLength = 64000;                       //for stereo
        MICbuffer.dwFlags = 0;

        // for recording wave format
        RecordWavFileFmt.wFormatTag = WAVE_FORMAT_PCM;
        RecordWavFileFmt.cbSize = 0;
        RecordWavFileFmt.nSamplesPerSec = 11025;
        RecordWavFileFmt.wBitsPerSample = 8;
        RecordWavFileFmt.nChannels = 1;
        RecordWavFileFmt.nBlockAlign = RecordWavFileFmt.nChannels * RecordWavFileFmt.wBitsPerSample / 8;
        RecordWavFileFmt.nAvgBytesPerSec = RecordWavFileFmt.nSamplesPerSec * RecordWavFileFmt.nBlockAlign;

        m_bOneFileExist = FALSE;
        show_spectrum_type=0;
        FigureWidth=230;
        FigureHeight=260;
        // ←
}

CSpeechProcPPCView::~CSpeechProcPPCView()
{
}

BOOL CSpeechProcPPCView::PreCreateWindow(CREATESTRUCT& cs)
{
        // TODO: Modify the Window class or styles here by modifying
        //  the CREATESTRUCT cs
        return CView::PreCreateWindow(cs);
}

//////////////////////////////////////////////////////////////////////////
// CSpeechProcPPCView drawing

void CSpeechProcPPCView::OnDraw(CDC* pDC)
{
```

```
	CSpeechProcPPCDoc* pDoc = GetDocument();
	ASSERT_VALID(pDoc);

	// TODO: add draw code for native data here
	// Put your own Digital Signal Processing codes here →
	if(show_spectrum_type==1){    // plot waveform
		// call drawing funtion in PlotXY.cpp and PlotXY.h
		DrawXY(pDC,Sample,NumSample,5,3,FigureWidth, FigureHeight);		}
	else if(show_spectrum_type==2){  // ------------ FFT
		double* data;
		int* dataAmp;
		int NumData;
		int i;

		NumData=(unsigned long)pow(2, (int)floor( log(NumSample)/log(2) ));
		data=new double[2*NumData+1];
		dataAmp=new int[NumData];
		data[0]=0;
		for(i=0;i<NumData;i++){
			data[2*i+1]=Sample[i];  // real part
			data[2*(i+1)]=0;  }     // imaginary part

		// call FFT function, in spectrum.cpp and spectrum.h
		four1(data, (unsigned long)NumData, 1);
		for(i=0;i<NumData;i++){
			dataAmp[i]=(int)10*log10(sqrt(data[2*i+1]*data[2*i+1]+data[2*(i+1)]*data[2*(i+1)] ));     }

		// call drawing funtion in PlotXY.cpp and PlotXY.h
		DrawXY(pDC,dataAmp,NumData,5,3,FigureWidth, FigureHeight);		}
	// ←

}

/////////////////////////////////////////////////////////////////////////////
// CSpeechProcPPCView diagnostics

#ifdef _DEBUG
void CSpeechProcPPCView::AssertValid() const
{
	CView::AssertValid();
}

void CSpeechProcPPCView::Dump(CDumpContext& dc) const
{
	CView::Dump(dc);
}

CSpeechProcPPCDoc* CSpeechProcPPCView::GetDocument() // non-debug version is inline
{
	ASSERT(m_pDocument->IsKindOf(RUNTIME_CLASS(CSpeechProcPPCDoc)));
	return (CSpeechProcPPCDoc*)m_pDocument;
}
#endif //_DEBUG

/////////////////////////////////////////////////////////////////////////////
// CSpeechProcPPCView message handlers

// ####### Open a File  ##########
void CSpeechProcPPCView::OnFileOpen()
{
	// TODO: Add your command handler code here
	// Put your own codes to open file →
	int i;
	int iRetn;
	WAVEFORMATEX WavFileFmt;    //  Defines the format of waveform audio data.
	BYTE* InDataBuf;          // buffer for read in data
	ULONG TotInSamples;       // number of sample
```

```
            OPENFILENAME ofn;  // This structure contains information the operating system uses
                                    // to initialize the system-defined Open or Save As dialog box.
                                   // After the user closes the dialog box, the system returns
                                   // information about the user's selection in this structure
            memset(&ofn,0,sizeof(ofn));   // Allocate memory for ofn
            ofn.lStructSize=sizeof(ofn);  // Initial setting for ofn
            ofn.lpstrFile=in_filename;
            ofn.nMaxFile=255;
            ofn.lpstrFilter=_T("Audio Files:*.wav\0*.wav\0All Files:*.*\0*.*\0\0");  // required file ext
            ofn.lpstrInitialDir=NULL;


            if(GetOpenFileName(&ofn)==TRUE){     // Show up the Open File Dialog Box
                 InDataBuf=new BYTE[MAXINSIZE];
                 iRetn=ReadWav(in_filename,&WavFileFmt,&TotInSamples,InDataBuf);  // file in filewav.cpp

                 if(iRetn!=0){
                          MessageBox(_T("Fail to load data"));
                          return;   }

                NumSample=TotInSamples;
                if( m_bOneFileExist == TRUE ){  // if there already exists a file, redefine the memory
                          delete[] Sample;  }

                m_bOneFileExist = TRUE;                    // set up the flag to indicate a file is in this application
                Sample=new int[NumSample];
                for(i=0;i<NumSample;i++){
                          Sample[i]=(int)InDataBuf[i];}
                delete[] InDataBuf;
                m_bOneFileExist = TRUE;   }
                //←
}

// ####### Save a File #############
void CSpeechProcPPCView::OnFileSave()
{
    // TODO: Add your command handler code here
  // put your codes here to deal with the reaction for this item →
  long i;
  OPENFILENAME ofn;

  if( m_bOneFileExist == FALSE ){
        MessageBox(_T("No data exist for saving out"));    }
  else{   // if there is a file in application, then we allow saving files
        memset(&ofn,0,sizeof(ofn));   // Allocate memory for ofn
        ofn.lStructSize=sizeof(ofn);  // Initial setting for ofn
        ofn.lpstrFile=out_filename;
        ofn.nMaxFile=255;
        ofn.lpstrFilter=_T("Audio Files:*.wav\0*.wav\0All Files:*.*\0*.*\0\0");  // required file ext
        ofn.lpstrInitialDir=NULL;

        BYTE* OutBuffer;
         OutBuffer = new BYTE[NumSample];
         for( i = 0; i < NumSample; i++){
              OutBuffer[i] = (BYTE)Sample[i]; }

        if(GetSaveFileName(&ofn)==TRUE){     // Show up the Save File Dialog Box
              WriteWav(&RecordWavFileFmt, NumSample, OutBuffer, out_filename); }}   // call WriteWav to save wave file
              //←

}

// ####### Start to record  ##########
// function was provided by Fall 2002 Group 4 iTalk5000: Josh Merti, Pall Kunchai, and Vijay Kumar
void CSpeechProcPPCView::OnFILEStartRecord()
{
              // TODO: Add your command handler code here
  // put your codes here to deal with the reaction for this item →
```

```
        DWORD callback = 0;
        DWORD instance = 0;
        DWORD open = 0;

        //Open microphone for recording
       if( (mr = waveInOpen(&hWaveIn, 0, &RecordWavFileFmt, callback, instance, open)) !=
            MMSYSERR_NOERROR ){
                MessageBox(_T("Fail in waveInOpen"));     return;      }

         //prepare the buffer for audio recording
        if( (mr = waveInPrepareHeader(hWaveIn, &MICbuffer, sizeof(MICbuffer))) != MMSYSERR_NOERROR)      {
                MessageBox(_T("Fail in waveInPrepareHeader"));       return;      }

        //if that succeeds, link the mic input data to buffer
        if((mr = waveInAddBuffer(hWaveIn, &MICbuffer, sizeof(MICbuffer))) != MMSYSERR_NOERROR)           {
                MessageBox(_T("Fail in waveInAddBuffer"));           return;      }

        //if that succeeds, start recording
        mr = waveInStart(hWaveIn);
        // ←
}


// ####### Stop Record  ##########
// function was provided by Fall 2002 Group 4 iTalk5000: Josh Merti, Pall Kunchai, and Vijay Kumar
void CSpeechProcPPCView::OnFILEStopRecord()
{
        // TODO: Add your command handler code here
        // put your codes here to deal with the reaction for this item →
        long i;

        //close microphone
        if((mr = waveInStop(hWaveIn)) != MMSYSERR_NOERROR)      {
                MessageBox(_T("Fail in waveInStop"));      return;      }

        //Reset microphone state so it can be reopened later
        if( (mr = waveInReset(hWaveIn)) != MMSYSERR_NOERROR)    {
                MessageBox(_T("Fail in waveInReset"));     return;      }

        if ( (mr = waveInClose(hWaveIn)) != MMSYSERR_NOERROR)  {          //close lpData buffer
                MessageBox(_T("Fail in waveInClose"));     return;      }

        //Reset buffer structure so it can be reused
        mr = waveInUnprepareHeader(hWaveIn, &MICbuffer, sizeof(WAVEHDR));

        NumSample = MICbuffer.dwBytesRecorded;

        if( m_bOneFileExist == TRUE ){
                delete[] Sample;}

        m_bOneFileExist = TRUE;
        Sample= new int[NumSample];

        for( i =0; i < NumSample; i++ ){
                Sample[i] = (BYTE)MICbuffer.lpData[i]; }
        // ←

}

// ####### Plot FFT ##########
void CSpeechProcPPCView::OnSpectrumFft()
{
        // TODO: Add your command handler code here
        // put your codes here to deal with the reaction for this item →
        show_spectrum_type =2;   // FFT
        CClientDC aDC(this);
        this->OnDraw(&aDC);
```

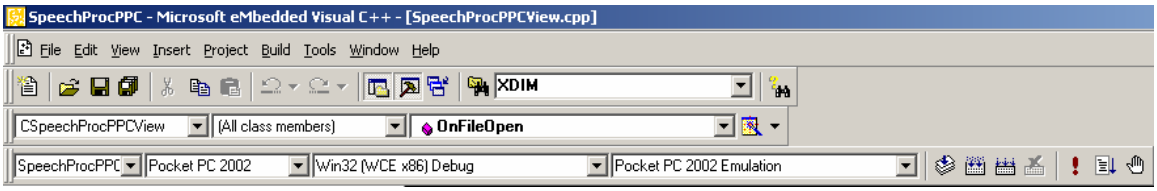
```
        // ←
}

// ####### Plot waveform #########
void CSpeechProcPPCView::OnSpectrumWaveform()
{
        // TODO: Add your command handler code here
       // put your codes here to deal with the reaction for this item →
        show_spectrum_type  =1;  //  waveform
        CClientDC aDC(this);
        this->OnDraw(&aDC);
       // ←
}
```

When compiling, some error messages on precompiled headers may show up in the *Output Window*. Please follow the solution in section IV.6.1 to deal with the files *filewav.cpp*, *PlotXY.cpp*, and *spectrum.cpp*.

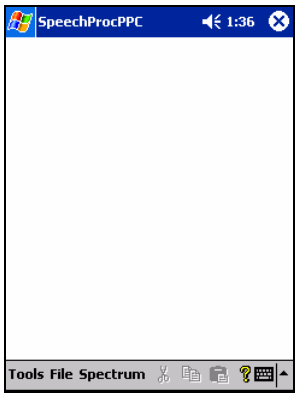
(f) Run your program on the emulator.

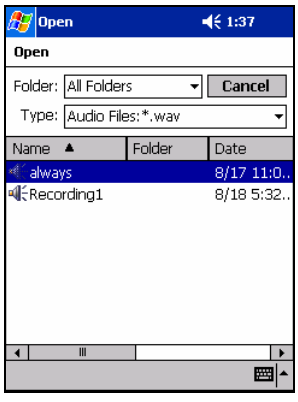
Select the Platform as *Pocket PC 2002*, *Win32 [WCE x86] Debug*, and *Pocket PC 2002 Emulation*, which is shown in the figure below.

Compile your program by and run it by



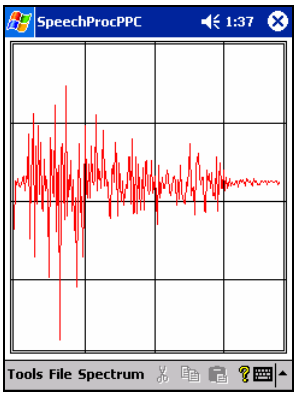
You will see the GUI on the emulator.



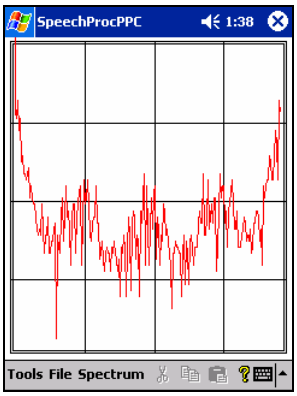


You can select a wave file by *File* → *Open*. To observe the waveform, you can click *Spectrum* → *Waveform*. To observe the FFT, click *Spectrum* → *FFT*.

Waveform



FFT



You can start to record a sound clip by clicking *File->REC start* and stop by *File -> REC stop*. You can view the waveform and FFT of this recorded sound. Also, you can save it as a wave file through *File -> Save*.

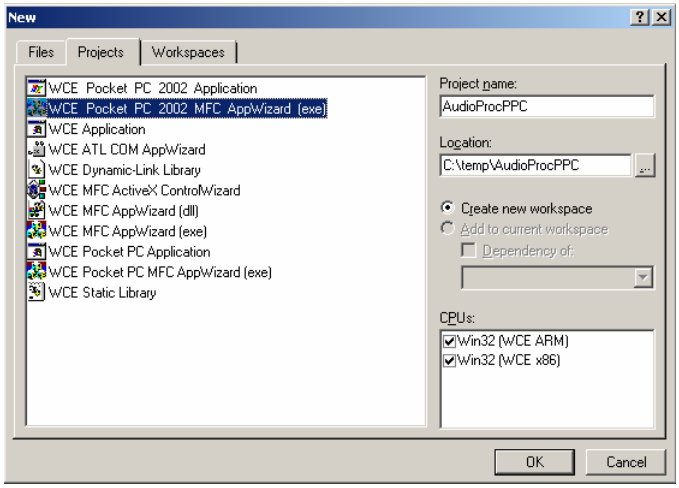
(g) Modification

You can extend your project by adding more functions under the *Spectrum* main menu item and setting different *show_spectrum_type* value and the corresponding reaction in *CSpeechProcView::OnDraw*. A useful reference and codes, named *Numerical Recipes*, can be obtained from http://www.nr.com.

5. eVC Demo Project-4: Digital Audio Processing – Digital Piano

In this demo project, you will design a digital piano and learn
(1) how to import external *.wav* file as internal resource, and
(2) how to use *PlaySound.dll* API.

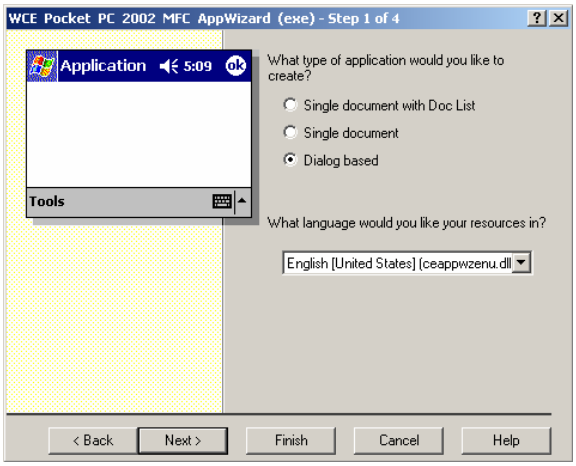
(a). Create a New Project by *File* → *New*



(1) Select "*WCE Pocket PC 2002 MFC AppWizard (exe)*" on the *Projects* tap
(2) Key in "*AudioProcPPC*" on *Project name* edit box and select a *Location* for this project. Also check "*Create new workspace*".
(3) Check "*Win32[WCE ARM]"* and "*Win32[WCE x86]"* on the *CPUs* box[25]
(4) Click "*OK*" and a *WCE Pocket PC 2002 MFC AppWizard* window will pop up.

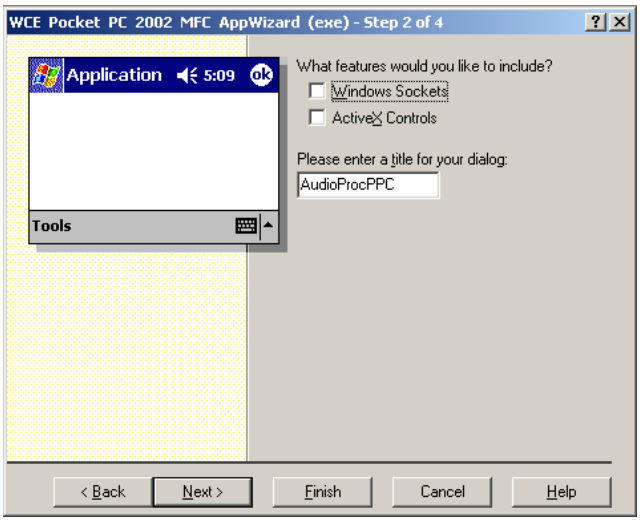
(b). WCE Pocket PC 2002 MFC AppWizard

(1) Choose "*Dialog Base*" and click "*Next*".

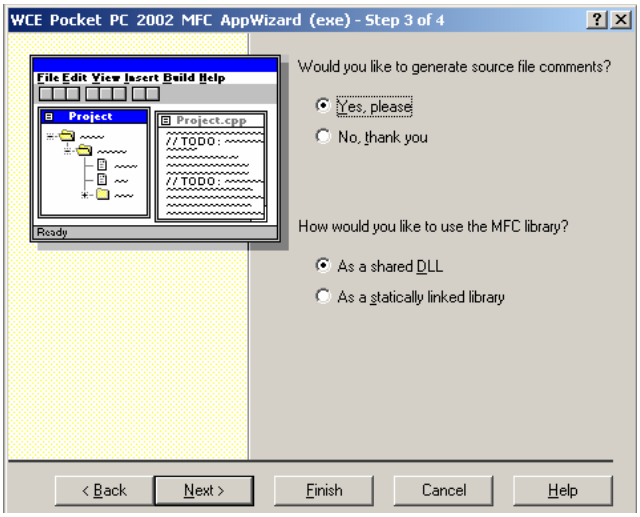


[25] If Pocket PC 2002 SDK is not available, you may create a new project by an older version of MFC AppWizard, such as *WCE MFC AppWizard* or *WCE Pocket PC MFC AppWizard*.

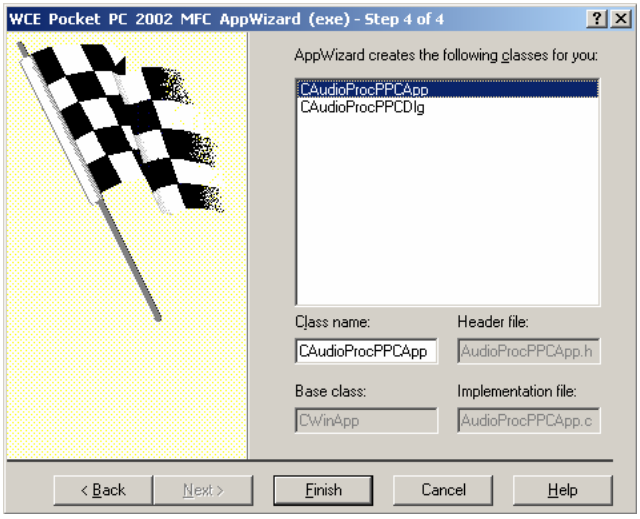
(2) Disable all features and set title as "*AudioProcPPC*". Click "*Next*".



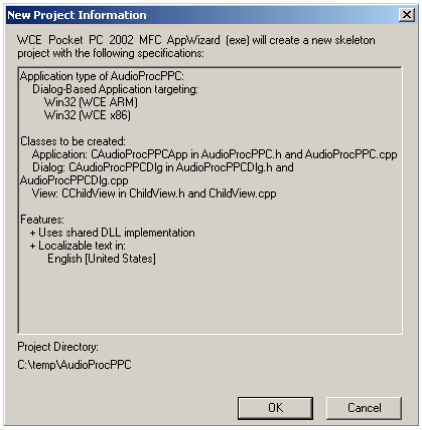
(5) Choose "*Generate source file comment*" and " *As a shared DLL*"



(4) Click "*Finish*" to finish the initial setting.



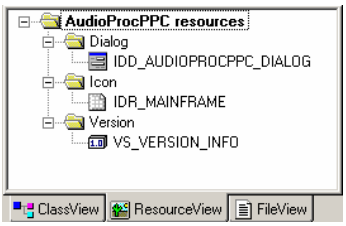
(5) AppWizard will summarize the features and files of new project you created. Click "*OK*" to close the AppWizard.


New Project Information
WCE Pocket PC 2002 MFC AppWizard (exe) will create a new skeleton project with the following specifications:
Application type of AudioProcPPC:
Dialog-Based Application targeting:
Win32 (WCE ARM)
Win32 (WCE x86)
Classes to be created:
Application: CAudioProcPPCApp in AudioProcPPC.h and AudioProcPPC.cpp
Dialog: CAudioProcPPCDlg in AudioProcPPCDlg.h and AudioProcPPCDlg.cpp
View: CChildView in ChildView.h and ChildView.cpp
Features:
+ Uses shared DLL implementation
+ Localizable text in:
English [United States]
Project Directory:
C:\temp\AudioProcPPC
OK
Cancel

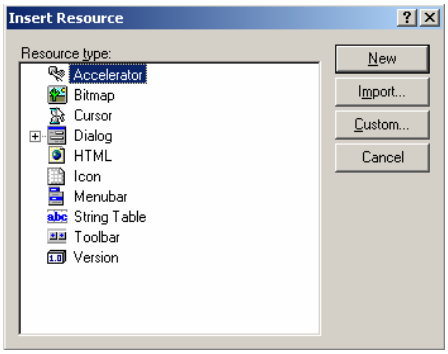
(c) Edit *Resource*:

There are two ways to read .wav files. One way is to read external wave file using the *_fopen* function. The other way is to import wave files during the compiling period and treat them as internal resources. In this project, we adopt the second approach.

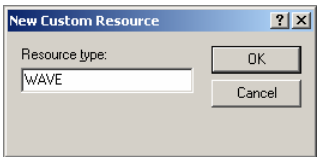
(1) *ResourceView*: To import .wav files into this project, we should start from the *ResourceView*, which is shown in the following figure.



(2) Insert New Resource: Right click on the "*AudioProcPPC resources*" folder and choose "*Insert*".

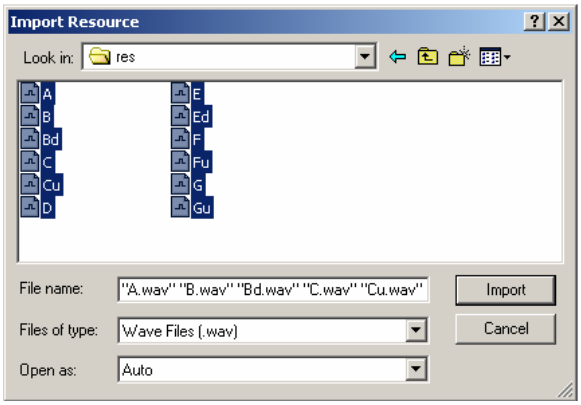


Click "*Custom*" and specify the *Resource type* as *WAVE*.

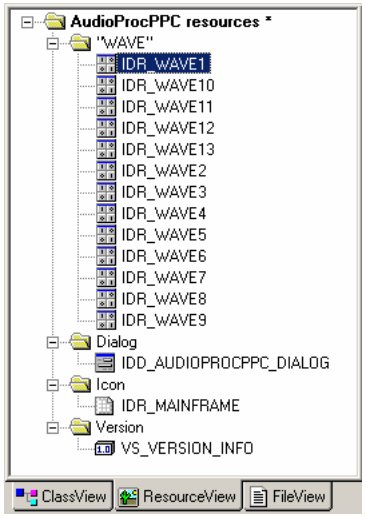


Thus, we create a *WAVE* resource.

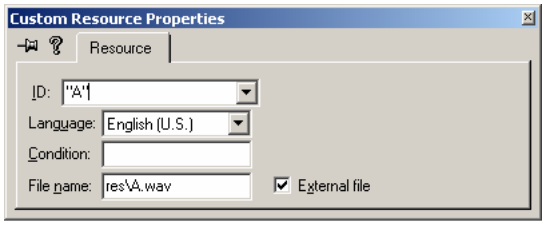
(3) Import .wav file: Put all .wav files under *\AudioProc\res* directory. Right click "*WAVE*" on the *ResourceView* tap and choose "*Import*". Select all wave files.



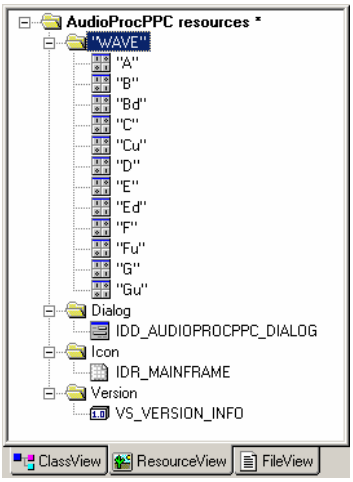
After importing, the *ResourceView* becomes the figure below.

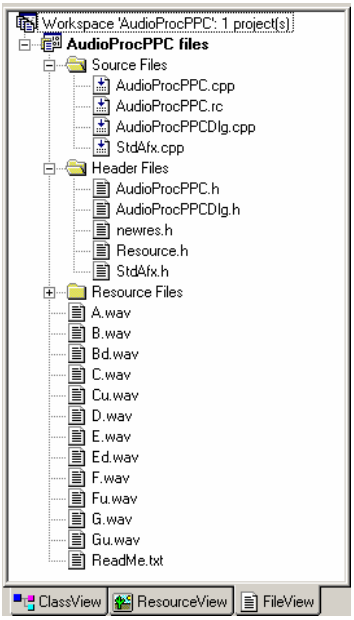


Delete the "*IDR_WAVE1*". Right click each "*IDR_WAVE*" and choose "*Properties*". A *Custom Resource Properties* dialog box will pop up.



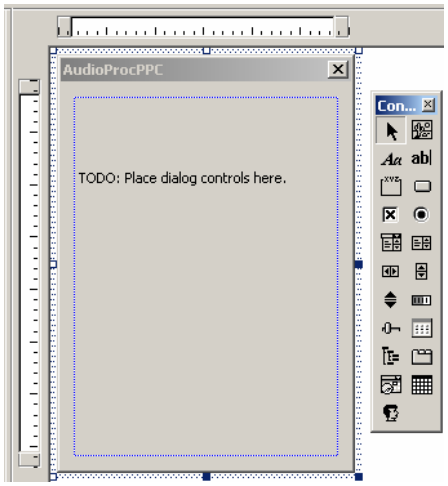
Change the text in the *ID* list box into the text in the *File name* edit box. For example, if we import file *A.wav*, and we will observe a string, *res\A.wav*, in the *File name* edit box. Change its *ID* into *"A"*. (It includes quotation marks). We can check the result of importing from the *ResourceView* and *FileView* tap.



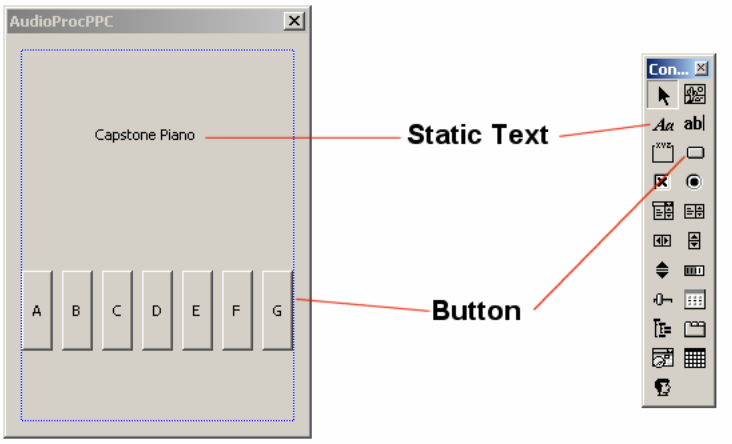


(d). Interface Design:

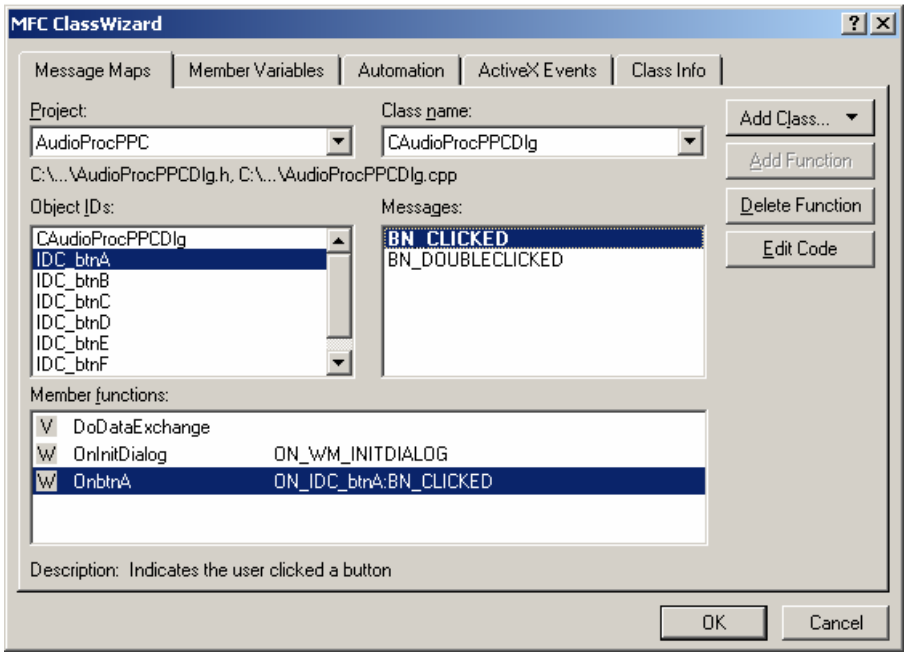
(1) Double click *Dialog→IDO_AUDIOPROCPPC_DIALOG* on the *ResourceView* tap.



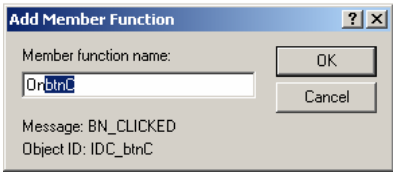
(2) *Controls*: Delete the "*TODO: Place dialog controls here*". Drag a *Static Text* from *Controls Toolbar* and drop on the dialog box. Right click and choose "Properties". Set the *Caption* as "*Capstone Piano*". Also, drag and drop a button. Change its width and height. To generate the same size for the other buttons, you can click the first button, copy, and paste it several times. To align those buttons, you can use "*Layout*" from eVC menu bar and choose "*Align*", "*Space Evenly*", and "*Make Same Size*". The final layout is shown in the following figure.



(3) *Messages and Member Functions*: We can set up *Messages* and *Member functions* using *ClassWizard*. We can use *View* → *ClassWizard* from eVC IDE menu bar to open it.



Click each "*IDC_btn*" item in the "*Object IDs*" window and click "*BN_CLICKED*" in the "Message" window. An "*Add Member Function*" box will show up. Click "*OK*" to add those member functions.



After setting up the required member functions, we can add our own codes.

(e) Edit *AudioProcPPCDlg.cpp*[26]

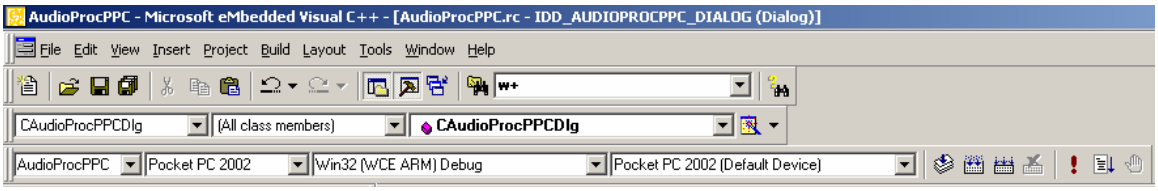
```
// AudioProcPPCDlg.cpp : implementation file
// Author: Guan-Ming Su
// Date: Aug 2002

#include "stdafx.h"
#include "AudioProcPPC.h"
#include "AudioProcPPCDlg.h"

#ifdef _DEBUG
#define new DEBUG_NEW
#undef THIS_FILE
static char THIS_FILE[] = __FILE__;
#endif

/////////////////////////////////////////////////////////////////////////////
// CAudioProcPPCDlg dialog

CAudioProcPPCDlg::CAudioProcPPCDlg(CWnd* pParent /*=NULL*/)
	: CDialog(CAudioProcPPCDlg::IDD, pParent)
{
	//{{AFX_DATA_INIT(CAudioProcPPCDlg)
		// NOTE: the ClassWizard will add member initialization here
	//}}AFX_DATA_INIT
	// Note that LoadIcon does not require a subsequent DestroyIcon in Win32
	m_hIcon = AfxGetApp()->LoadIcon(IDR_MAINFRAME);
}

void CAudioProcPPCDlg::DoDataExchange(CDataExchange* pDX)
{
	CDialog::DoDataExchange(pDX);
	//{{AFX_DATA_MAP(CAudioProcPPCDlg)
		// NOTE: the ClassWizard will add DDX and DDV calls here
	//}}AFX_DATA_MAP
}

BEGIN_MESSAGE_MAP(CAudioProcPPCDlg, CDialog)
	//{{AFX_MSG_MAP(CAudioProcPPCDlg)
	ON_BN_CLICKED(IDC_btnA, OnbtnA)
	ON_BN_CLICKED(IDC_btnB, OnbtnB)
	ON_BN_CLICKED(IDC_btnC, OnbtnC)
	ON_BN_CLICKED(IDC_btnD, OnbtnD)
	ON_BN_CLICKED(IDC_btnE, OnbtnE)
	ON_BN_CLICKED(IDC_btnF, OnbtnF)
	ON_BN_CLICKED(IDC_btnG, OnbtnG)
	//}}AFX_MSG_MAP
END_MESSAGE_MAP()

/////////////////////////////////////////////////////////////////////////////
// CAudioProcPPCDlg message handlers

BOOL CAudioProcPPCDlg::OnInitDialog()
{
	CDialog::OnInitDialog();

	// Set the icon for this dialog.  The framework does this automatically
	//  when the application's main window is not a dialog
	SetIcon(m_hIcon, TRUE);			// Set big icon
	SetIcon(m_hIcon, FALSE);		// Set small icon

	CenterWindow(GetDesktopWindow());	// center to the hpc screen

	// TODO: Add extra initialization here
```

[26] Notice that "***// Add your own code →***" and "***//←***" indicates that you may put some codes in these areas. In this example, we use italic red font for the added codes (to distinguish from the codes already automatically generated by eVC).

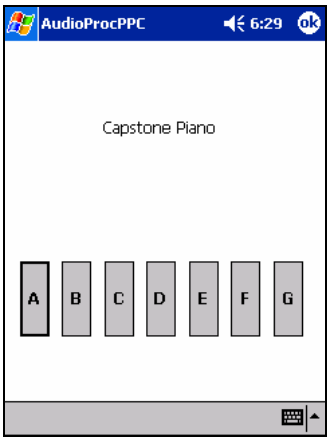
```
	return TRUE;  // return TRUE  unless you set the focus to a control
}



void CAudioProcPPCDlg::OnbtnA()
{
	// TODO: Add your control notification handler code here
	PlaySound(_T("A"), :: AfxGetInstanceHandle(), SND_RESOURCE | SND_SYNC );
}

void CAudioProcPPCDlg::OnbtnB()
{
	// TODO: Add your control notification handler code here
	PlaySound(_T("B"), :: AfxGetInstanceHandle(), SND_RESOURCE | SND_SYNC );
}

void CAudioProcPPCDlg::OnbtnC()
{
	// TODO: Add your control notification handler code here
	PlaySound(_T("C"), :: AfxGetInstanceHandle(), SND_RESOURCE | SND_SYNC );
}

void CAudioProcPPCDlg::OnbtnD()
{
	// TODO: Add your control notification handler code here
	PlaySound(_T("D"), :: AfxGetInstanceHandle(), SND_RESOURCE | SND_SYNC );
}

void CAudioProcPPCDlg::OnbtnE()
{
	// TODO: Add your control notification handler code here
	PlaySound(_T("E"), :: AfxGetInstanceHandle(), SND_RESOURCE | SND_SYNC );
}

void CAudioProcPPCDlg::OnbtnF()
{
	// TODO: Add your control notification handler code here
	PlaySound(_T("F"), :: AfxGetInstanceHandle(), SND_RESOURCE | SND_SYNC );
}

void CAudioProcPPCDlg::OnbtnG()
{
	// TODO: Add your control notification handler code here
	PlaySound(_T("G"), :: AfxGetInstanceHandle(), SND_RESOURCE | SND_SYNC );
}
```

(f). Run your program on the real Pocket PC Device

Because the emulator does not support the functionality of a speaker, we should testify our program on the real device. Select the Platform as *Pocket PC 2002*, *Win32 [WCE ARM] Debug*, *Pocket PC 2002 [Default Device]*, which is shown in the following figure.


AudioProcPPC - Microsoft eMbedded Visual C++ - [AudioProcPPC.rc - IDD_AUDIOPROCPPC_DIALOG (Dialog)]
File Edit View Insert Project Build Layout Tools Window Help
CAudioProcPPCDlg
(All class members)
CAudioProcPPCDlg
AudioProcPPC
Pocket PC 2002
Win32 (WCE ARM) Debug
Pocket PC 2002 (Default Device)

Click the compile icon to compile your program and then click the execute icon to run it. You will see the Capstone Piano!



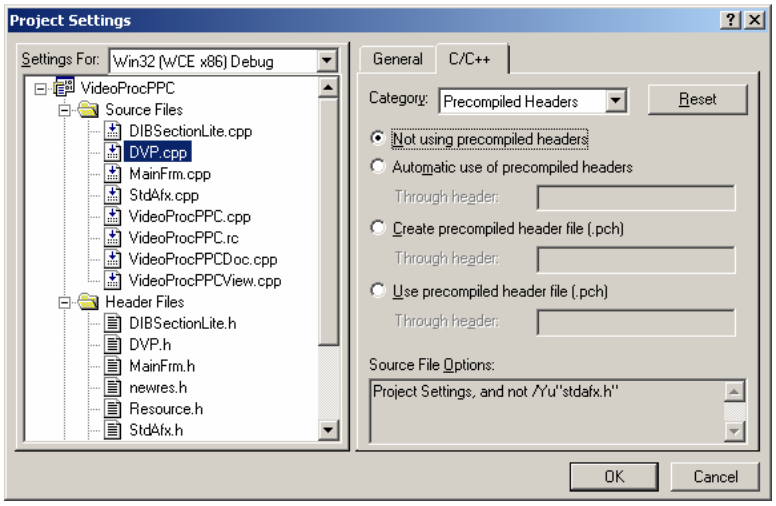
Remember to turn on your Pocket PC's speaker. You can click each button and play this piano. Enjoy it!

6. Troubleshooting

(a) **Q:** How to solve the problem while eVC compiles a project after importing new files and the *Output Window* shows a message shown below.

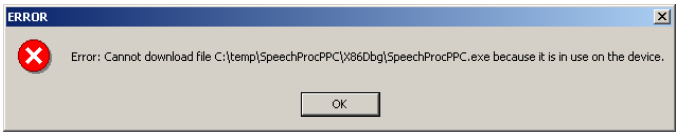
```
C:\temp\VideoProcPPC\DVP.cpp(64) : fatal error C1010: unexpected end of file while looking for precompiled
header directive
Generating Code...
Error executing cl.exe.

VideoProcPPC.exe - 1 error(s), 0 warning(s)
```

A: This is a problem with the precompiled header. eVC will generate precompiled headers to save some time when you recompile this project. However, when you add new files into this project, these new files do not have the precompiled headers. eVC cannot find their precompiled headers and will output the message above. To solve this problem, you can right click on these *.cpp* files on the *FileView* tap, and choose the *Setting*; or from eVC menu bar, click *Project* → *Setting*. You will see a *Project Settings* window.



On *C/C++* tap, choose the *Category* as *Precompiled Headers* and check "*Not using precompiled headers*" for those new imported files.

(b) **Q:** When eVC recompiles a program, the *Output Window* shows a message with "Cannot not find *Debug/*.exe*, error executing *link.exe"* or a error message box



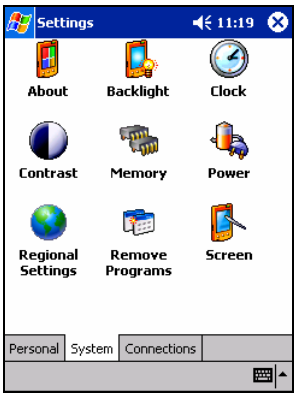
A: This is because the **.exe* is currently running under the debug mode. Therefore, you need to terminate this program before you recompile it. It is noteworthy that even if you click "*OK*" button to close this program and it disappears on your screen, this program is still running in main memory under the Pocket PC 2002 OS. Be aware of that it happens both on emulator and real device. You need to terminate this program using the following procedures.

Step-1: Click *Start*→ *Settings*, a *Settings window* will show up.

Step-2: Choose *Memory* on the *System* tap of the *Settings* Window. Another window will show up.

Step-3: Click on the *Running Programs* tap, and we will see a *Running Program List*. Click on the executing program **.exe* and press the *Stop* button to terminate it.

Step 1



Step 2

Step 3

(c) **Q:** How can I transfer (import/export) files to emulator?

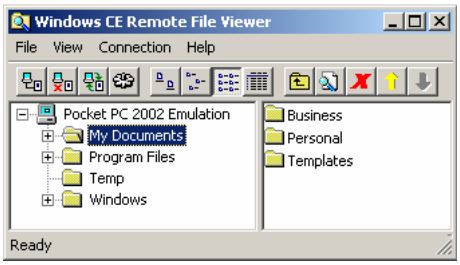
A: We need to handle WinCE emulator and Pocket PC 2002 emulator differently.

(1) For WinCE emulator, you can directly access and copy/paste files in *C:\Window CE Tools\wce300\MS Pocket PC\emulation\palm300.* This folder is the root directory of a WinCE emulator.

(2) For Pocket PC 2002 emulator, we should use *Windows CE remote File Viewer*. There are two ways to open this viewer.

(i) The first way is already mentioned in section III.1.(b).(3). We can open the viewer from the *Tools* on the *eVC* menu.

(ii) You can directly run this viewer by double clicking it in the folder *C:\Program Files\Windows CE Tools\ Common\Playman\bin\cefilevw.exe* You will see the File Viewer as follows.



You can import/export files by clicking the two yellow arrows or the *File* on menu bar.

Note: Once you restart the Pocket PC 2002 emulator, all files will be cleared. In this case, you should export files to emulator again.

(d) **Q:** How can I convert *char* to *Unicode*?

A:

(1) WinCE uses *Unicode* by which each character is represented by 2 bytes. The easiest way to convert *char* to *Unicode* is to use the *_T()* function. For example, to convert "*filenamein*" to *Unicode*, you can simply use *_T("filenamein")*. To declare a *Unicode* array, you should use *TCHAR* instead of *char*.

(2) You also can convert string between ANSI character and Unicode by calling C run-time functions.
   (i) mbstowcs - Convert a multi-byte (ANSI) string to wide character string (Unicode)
   (ii) wcstombs - Convert a wide character string to multi-byte string

A small example is listed in the below table.

```
WCHAR szwcBuffer[100];
Char szBuffer[100];

Char* lpszConvert = "ANSI string to convert";
WCHAR* lpszwcConvert = _T("Unicode string to convert");
Int nChars;

nChars = mbstowcs(szwcBuffer, lpszConvert, 100);
nChars = wcstombs(szBuffer, lpszwcConvert, 100);
```

(e) **Q:** How can I detect the events of hardware control buttons, such as navigation buttons, on the Pocket PC front panel?
A: Hardware control buttons are treated as keyboard keys. Pressing a hardware control keys results in *WM_KEYDOWN* and *WM_KEYUP* messages as well as a *WM_CHAR* message if the virtual key matches a Unicode character. Here is an example using *WM_KEYDOWN*. Click *View* → *ClassWizard* from eVC menu bar, double click *WM_KEYDOWN* in the *messages* list box. You can edit codes by pressing "*Edit Code*".

```
void CHardwareKeyDemoDlg::OnKeyDown(UINT nChar, UINT nRepCnt, UINT nFlags)
{
        // TODO: Add your message handler code here and/or call default
        switch(nChar){
        case VK_LEFT:
                MessageBox(_T("Left navigation key is pressed"));
                break;
        case VK_RIGHT:
                MessageBox(_T("Right navigation key is pressed"));
                break;
        case VK_UP:
                MessageBox(_T("Up navigation key is pressed"));
                break;
        case VK_DOWN:
                MessageBox(_T("Down navigation key is pressed"));
                break;      }

        CDialog::OnKeyDown(nChar, nRepCnt, nFlags);
}
```

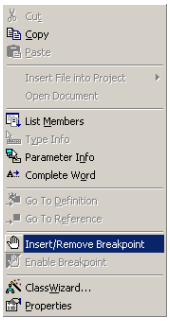
(f) **Q:** How can I debug programs?
A: Under Windows Programming environment, we do not have a command prompt window to print out data using *printf* or *cout*. There are several ways to debug Windows programs.

(1) Use the *MessageBox* function. E.g.

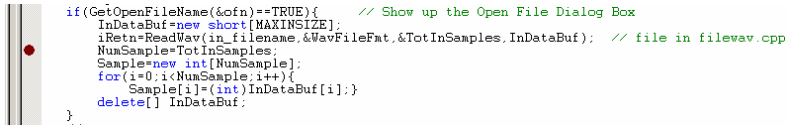
MessageBox(_T("Cannot Open files"),MB_OK).

(2) Use the eVC Debugger.

(i) In the *Edit Window*, right click the line where you want to set a breakpoint, and click *Insert/Remove Breakpoint*.

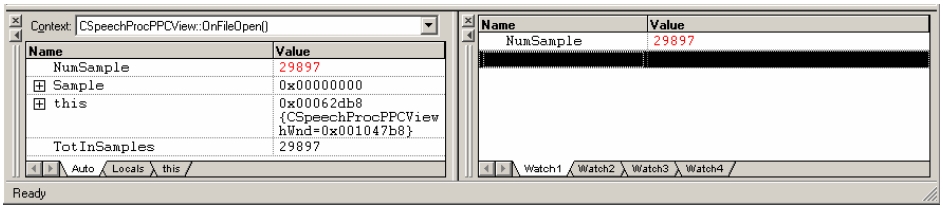


Here is an example. After setting a breakpoint for the line, *NumSample=TotInSamples*, you will see a red dot in front of it.



(ii) Run the debugger by *Build→ Start Debug* from the eVC menu bar. You will see the debug toolbar.

(iii) Execute your program. The Debugger will stop at the breakpoint you set. You can observe the variables and objects on the bottom of eVC IDE shown below. The left window is the *Variables window* and the right one is the *Watch Window*. You can add variables that you are interested in the *Watch Window*. In this example, we add *NumSample*.



(3) Use *Trace* function. Please refer to the MSDN Help.

Part V. Further Reference

1.eMbedded Visual Tools' built-in Help

Both eVB and eVC have built-in *Help* accessible from their menu bars. It offers a lot of useful material about Pocket PC programming.

2.Books:

(a) Nick Grattan: Pocket PC, Handheld PC Developer's Guide with Microsoft eMbedded Visual Basic, Prentice Hall PTR, 2001.
(b) Chris Tacke and Timothy Bassett, EMbedded Visual Basic: Windows CE and Pocket PC Mobile Applications, Sams, 2001.
(c) Douglas Boling: Programming Windows CE, Microsoft Press, 2001.
(d) Nick Grattan and Marshall Brain: Windows CE 3.0 Application Programming, Prentice Hall PTR, 2000.
(e) eBooks: eVB and eVC for Windows CE are very similar to VB and VC for desktop. You can find VB, VC, and MFC eBooks from http://www.netlibrary.com.

3. Web Sites

(a) Microsoft Pocket PC: http://www.microsoft.com/mobile/pocketpc/default.asp
(b) Microsoft MSDN: http://msdn.microsoft.com
(c) Pocket PC Developer Network: http://www.pocketpcdn.com/
(d) Pocket PC magazine: http://www.pocketpcmag.com
(e) CodeGuru: http://www.codeguru.com/
(f) Code Project: http://www.codeproject.com/
(g) FunctionX: http://www.functionx.com/visualc/